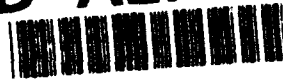


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**THE MECHANICAL PROPERTY DATA BASE FROM AN
AIR FORCE/INDUSTRY COOPERATIVE TEST PROGRAM ON ADVANCED ALUMINUM
ALLOYS (2091 SHEET, PLATE, AND 8090 EXTRUSION)**

MARYANN PHILLIPS and STEVEN R. THOMPSON
Materials Engineering Branch
Systems Support Division

June 1993

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Interim Report for Period November 1988 - December 1992

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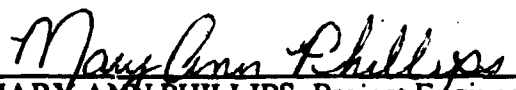
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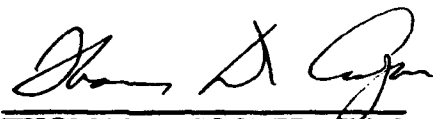
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PREFACE

This report was prepared by the Materials Engineering Branch (WL/MLSE), Systems Support Division, Materials Directorate, Wright Laboratory, Wright-Patterson Air Force Base, Ohio, under Project 2418, "Metallic Structural Materials," Task 241807, "Systems Support," Work Unit 24180703, "Engineering and Design Data."

The authors would like to thank the participants General Dynamics CA, Martin Marietta LA, McDonnell Aircraft Company MO, Northrop Corporation CA, McDonnell Douglas Astronautics CA, U.S. Army Material Technology Laboratory MA, and the Air Force.

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PREFACE

This report was prepared by the Materials Engineering Branch (WL/MLSE), Systems Support Division, Materials Directorate, Wright Laboratory, Wright-Patterson Air Force Base, Ohio, under Project 2418, "Metallic Structural Materials," Task 241807, "Systems Support," Work Unit 24180703, "Engineering and Design Data."

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SECTION 1

INTRODUCTION

High performance aerospace systems are dependent on materials that are lighter, have improved mechanical properties, and/or offer a cost savings. Aluminum alloys that met these criteria were the newly developed aluminum-lithium alloys and the second generation powder metallurgy alloys.

In 1985, the Air Force along with the aerospace community found it important to investigate the potential of these promising aluminum alloys. A cooperative program was formed by the Wright Laboratory Materials Directorate, Systems Support Division, and a number of aerospace industries. The Air Force would obtain the test material from the producers, compile the test data, and submit reports to the participants. The participants agreed to support the program by performing mechanical property tests which include tension, compression, bearing, shear, fracture toughness, and fatigue related properties (S/N, da/dn). The Air Force elected to perform spectrum fatigue crack growth testing on most alloys. A list of participants is shown in the following table.

This Interim report contains the aluminum-lithium alloys produced by Alcoa 2091 0.063 inch thick sheet, 2091 0.144 inch thick sheet, 2091 0.5 inch plate, 8090 hat extrusion and 8090 L extrusion. Comparisons to other materials and ranking of materials are generally avoided since each potential application may be based on different evaluation criteria.

TABLE
PARTICIPANTS AND ADVANCED ALUMINUM ALLOYS
in the COOPERATIVE TEST PROGRAM

PARTICIPANTS	ALUMINUM LITHIUM ALLOYS										P/M ALUMINUM ALLOYS								
	PECHINEY	ALCAN	IncoMAP	ALCOA	REYNOLDS	KAISER	ALCOA												
	2091-T3 Sheet (0.063")	2091-T351 Plate (0.420")	2091-T6 Forging	8090-T851 T Extrusion	8090-T851 Extrusion	8090-T8771 Plate (1.75")	PM IN905XL Forging	PM AL905XL Forging	2091-T3 Sheet (0.063")	2091-T3 Sheet (0.144")	2091-T6 Plate (0.50")	8090 Extrusion	Weldable 049 RXS15 Plate (0.5")	7064-T74511 Extrusion	7064-T74 Forging	CW67 Sheet (0.063")	CW67 Plate (0.40")	CW67 Extrusion	CW67 Forging
Air Force WPAFB, OH	x				x	x	x	x	x	x	x	x		x	x			x	x
Army, MA												x	x						
AVCO, TN									x										
Boeing, WA	x	x	x	x															
Douglas Aircraft, CA								x	x	x	x	x	x						
General Dynamics, CA	x	x							x	x	x		x						
General Dynamics, TX	x	x	x	x			x		x	x	x	x							
Grumman Aerospace, NY	x	x			x		x							x	x			x	x
Jet Propulsion, CA								x					x						
Lockheed, CA	x		x					x	x		x								
Lockheed, GA		x			x				x	x									x
LTV, TX	x		x				x	x	x			x		x	x			x	
Martin Marietta, LA	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x
McDonnell Douglas Astro, CA									x				x						
McDonnell Douglas Helicopter, AR								x											
McDonnell Douglas Missile Sys, MO													x						
McDonnell Aircraft, MO	x						x	x	x							x	x		x
NASA, VA					x		x	x					x						
Naval Air Development Center		x		x				x			x								x
Northrop, CA	x	x	x		x	x	x	x	x	x	x	x	x						
Sikorsky, CT							x		x						x		x		x
Sundstrand, IL													x						
Wyman-Gordon								x											

SECTION 2

MATERIALS AND TESTS

The Alcoa aluminum-lithium alloys were received on various dates: 2091-T3 0.063-inch sheet October 1988, 2091-T3 0.144-inch sheet March 1988, 2091-T8 0.5-inch plate March 1989, and 8090-T8 hat extrusion and 8090-T8 L extrusion September 1991. The 2091 was developed for maximum damage tolerance and 8090 for damage tolerance and higher strength.

The 2091-T3 0.063-inch sheet was tested as received by the Air Force and Martin Marietta. However, Northrop and McDonnell aircraft Company heat treated the alloy to a T8 condition. The 2091-T3 0.144-inch sheet was tested as received by the Air Force, Martin Marietta and McDonnell Douglas Astronautics. However, General Dynamics aged their material at 16 and 32 hours at 335°F and Northrop heat treated their material to a T8X temper. The 2091-T8 0.5-inch plate was tested as received. The dimensions of the 8090-T8 hat and L-extrusion are shown in Appendix M Figure M1 and Figure M2 respectively. The L-extrusion had to be cut for achieving the T8 condition making a thin and a thick piece. The L-extrusion was received in two pieces (0.60" x 4.00" x length and 1.55" x 1.55" x length).

Mechanical properties, (tension, compression, bearing, shear, and fracture toughness) fatigue and constant amplitude fatigue crack growth tests were tested according to ASTM standards, unless otherwise specified.

Spectrum tests were performed by the Air Force using FALSTAFF (a severe fatigue environment) and Mini-TWIST (a moderately intense fatigue environment) spectrums.

SECTION 3

PRESENTATION

Each participant compiled a data package which contained the data they generated. Some of these data packages contained discussions and in other cases, only the data were provided. The tensile, compression, bearing, and shear are put in tabular form. Fracture toughness, fatigue, fatigue crack growth, and spectrum fatigue crack growth data were placed in tabular and graphical form.

SECTION 4

RESULTS AND DISCUSSION

The data generated by the participants on the 2091 sheet, plate, and 8090 extrusions are in the Appendices. The following table lists the aluminum-lithium alloy, form, and the appendix in which the data can be found.

Table
Contents of Appendices

Aluminum-Lithium Alloy	Form	Appendix
2091-T3	0.063" Sheet	J
2091-T8	0.063" Sheet	J
2091-T3	0.144" Sheet	K
2091-T8	0.144" Sheet	K
2091-T8	0.500" Plate	L
8090-T8	Hat Extrusion	M
8090-T8	L-Extrusion	M

SECTION 5

CONCLUSIONS

Seven aerospace laboratories participated in generating data on the 2091 sheet, plate, and 8090 extrusions for the cooperative test program. These data combined with previous interim reports on the Air Force/Industry Cooperative Test Program on Advanced Aluminum Alloys provide an extensive data base on aluminum-lithium alloys.

APPENDIX J

**2091-T3 and 2091-T8
0.063-Inch Sheet**

TABLE J1

TENSILE RESULTS FOR ALCOA

2091-T3 SHEET (0.063" X 48" X 48")

COMPANY	TEST TEMP (DEGREES F)	ORIENT- ATION	ULTIMATE STRENGTH (KSI)	YIELD STRENGTH (KSI)	ELONG (%)	RA (%)	E (MSI)
MARTIN	RT	LONG	62.5	48.1	19.0	23.0	10.8
MARIETTA,			61.1	47.0	19.5	23.0	10.6
LOUISIANA			61.7	47.5	21.0	23.0	10.1
AIR FORCE	RT	LONG	60.8	47.6	22.4	24.8	
			60.7	47.6	25.1	23.1	
			60.4	47.5	22.9	23.1	
		AVERAGE	61.2	47.6	21.7	23.3	10.5
		STANDARD DEVIATION	0.8	0.4	1.0	0.3	0.4

TABLE J2

TENSILE RESULTS FOR ALCOA

2091-T3 SHEET (0.063" X 48" X 48")

COMPANY	TEST TEMP (DEGREES F)	ORIENT- ATION	ULTIMATE STRENGTH (KSI)	YIELD STRENGTH (KSI)	ELONG (%)	RA (%)	E (MSI)
AIR FORCE	RT	45	60.6	40.4	23.4	27.3	
			60.6	40.4	22.9	25.3	
			60.8	41.1	21.8	26.4	
		AVERAGE	60.7	40.6	22.7	26.3	
		STANDARD DEVIATION	0.1	0.4	0.8	1.0	

TABLE J3

TENSILE RESULTS FOR ALCOA

2091-T3 SHEET (0.063" X 48" X 48")

COMPANY	TEST TEMP (DEGREES F)	ORIENT- ATION	ULTIMATE STRENGTH (KSI)	YIELD STRENGTH (KSI)	ELONG (%)	RA (%)	E (MSI)		
AIR FORCE	RT	60	62.4	41.9	23.6	24.5			
			60.5	39.7	20.4	25.1			
			60.5		22.1	26.2			
			AVERAGE			61.1	40.8	22.0	25.3
			STANDARD DEVIATION			1.1	1.6	1.6	0.9

TABLE J4

TENSILE RESULTS FOR ALCOA

2091-T3 SHEET (0.063" X 48" X 48")

COMPANY	TEST TEMP (DEGREES F)	ORIENT- ATION	ULTIMATE STRENGTH (KSI)	YIELD STRENGTH (KSI)	ELONG (%)	RA (%)	E (MSI)
MARTIN MARIETTA, LOUISIANA	RT	L TRANS	65.0	43.2	11.0	19.0	10.4
			65.8	44.5	19.0	19.0	10.9
			65.5	42.7	17.0	19.0	8.9
AIR FORCE	RT	L TRANS	63.9	42.7	17.1	20.7	
			63.5	42.1	17.9	21.4	
			64.2	43.7	19.0	21.2	
		AVERAGE	64.7	43.2	16.8	20.1	10.1
		STANDARD DEVIATION	0.9	0.9	3.0	1.2	1.0

R-CURVE FOR 2091-T3, .063 inch SHEET
(longitudinal)

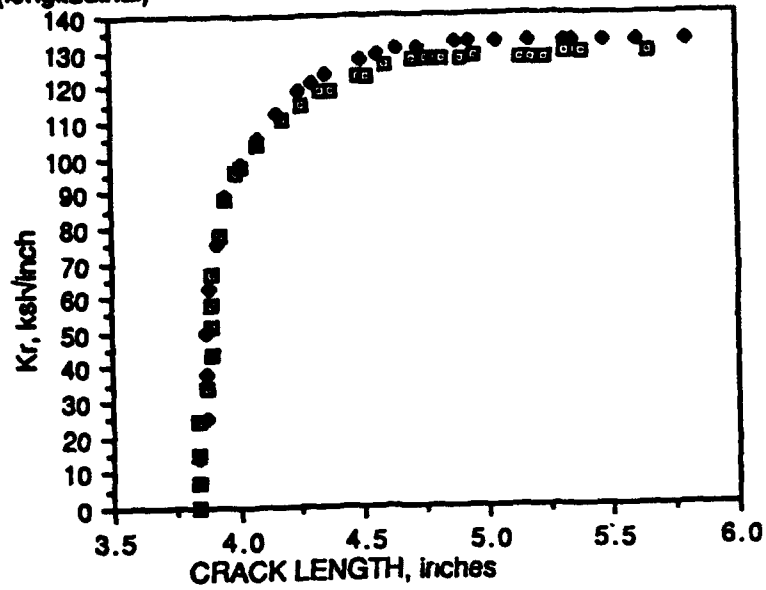


Figure J1. R-Curve Results for 2091-T3 0.063 inch Sheet
(L-T Orientation).
Martin Marietta.

R-CURVE FOR 2091-T3, .063 inch SHEET
(transverse)

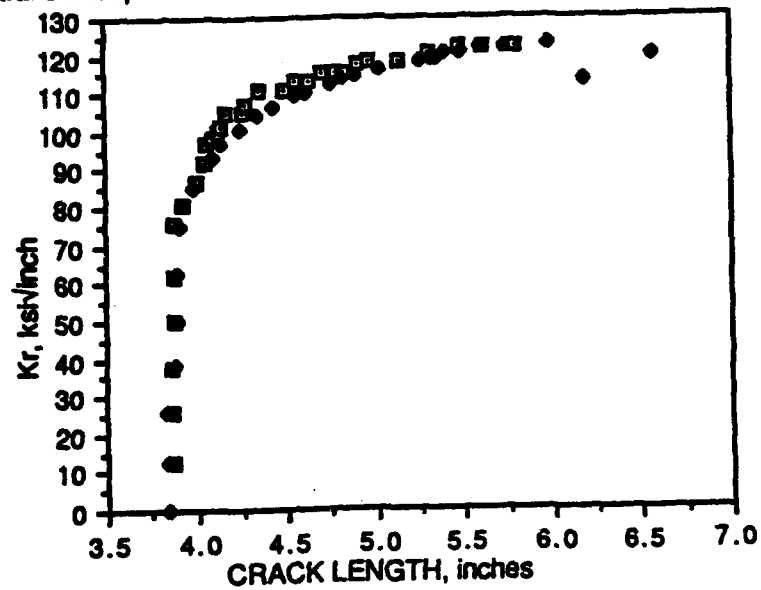


Figure J2. R-Curve Results for 2091-T3 0.063 inch Sheet
(T-L Orientation).
Martin Marietta.

R-CURVE FOR 2091, .063 inch Sheet
(longitudinal)
(effective crack length adjusted for plastic zone)

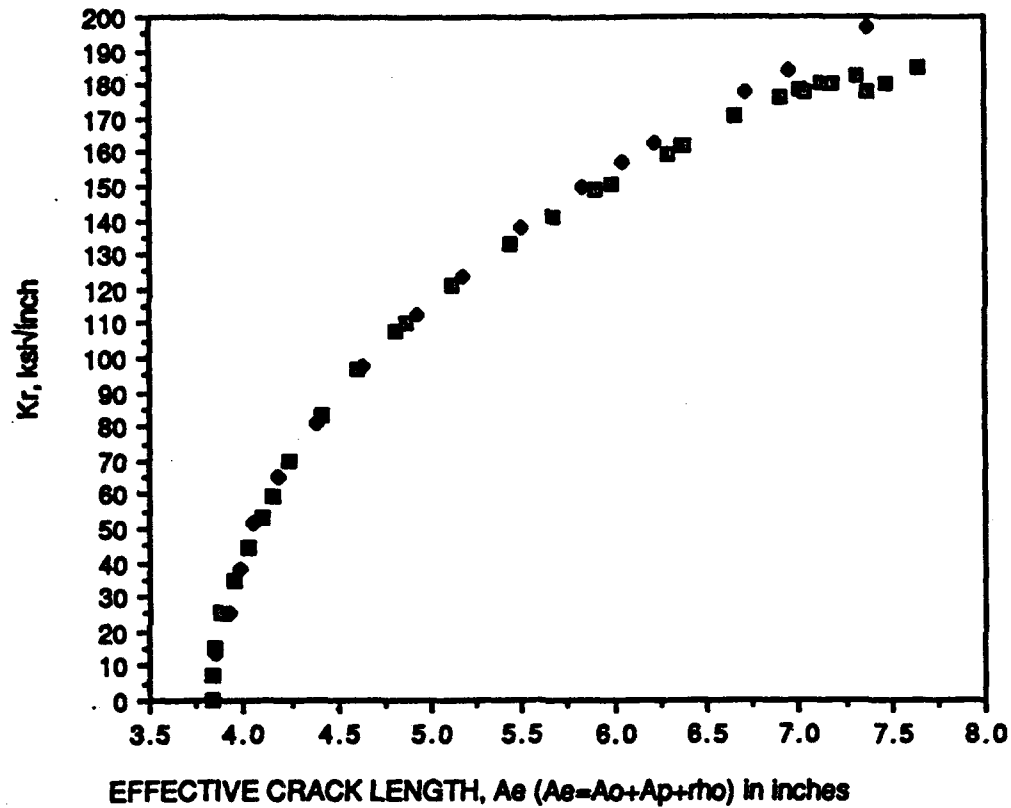


Figure J3. R-Curve Results for 2091-T3 0.063 Inch Sheet,
with Effective Crack Length Adjusted for
Plastic Zone (L-T Orientation).
Martin Marietta.

R-CURVE FOR 2091-T3, .063 inch SHEET
(transverse)
(effective crack length adjusted for plastic zone)

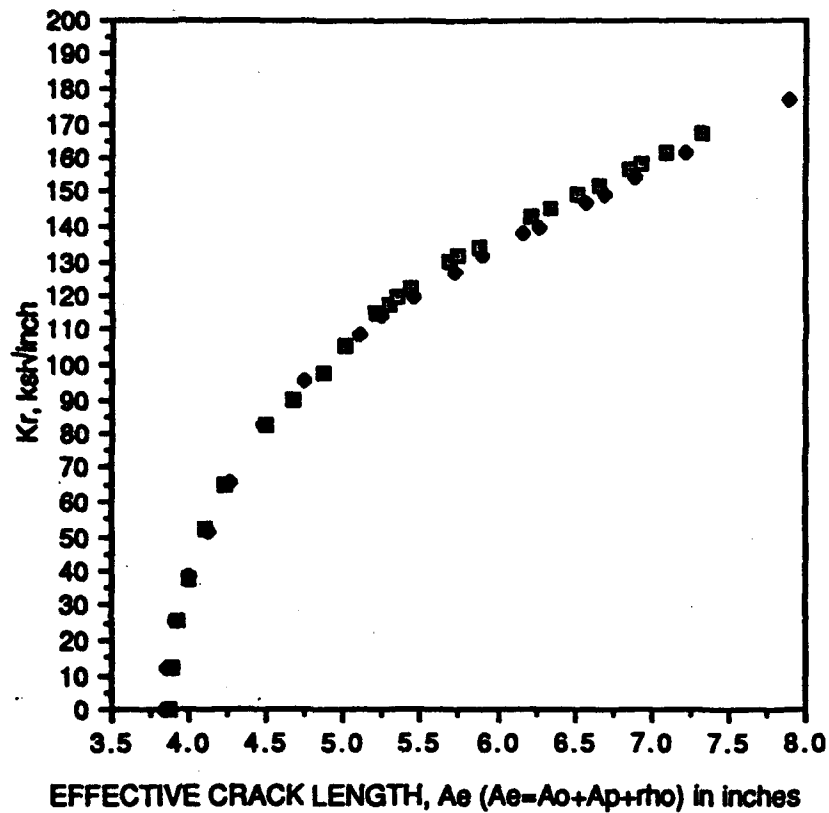


Figure J4. R-Curve Results for 2091-T3 0.063 Inch Sheet,
with Effective Crack Length Adjusted for
Plastic Zone. (T-L Orientation).
Martin Marietta.

TABLE J5

R-Curve Data Associated with Figures J1 and J3

DATA FOR SPECIMEN NO. 1

2091-T3 LONGITUDINAL SHEET

Load, kips	Half Crack Length (a), inch	Half Crack Length (a + rho), inch	Corresponding Fracture Toughness, ksi $\sqrt{\text{inch}}$	
			Not Adjusted	Adjusted for Plasticity
0	3.835	3.835	0.0	0.0
3.0	3.835	3.838	7.4	6.9
6.1	3.835	3.851	15.0	15.1
10.1	3.835	3.879	24.9	25.1
13.8	3.870	3.955	34.2	34.6
17.4	3.890	4.027	43.3	44.1
20.8	3.895	4.095	51.8	53.2
23.1	3.900	4.150	57.5	59.5
26.7	3.900	4.241	66.5	69.6
30.9	3.925	4.416	77.3	83.5
34.9	3.950	4.613	87.7	97.0
37.7	3.995	4.813	95.5	107.7
38.3	4.015	4.873	97.3	110.3
40.4	4.080	5.113	103.7	121.3
42.5	4.180	5.437	110.9	133.5
43.4	4.255	5.667	114.6	141.5
44.3	4.330	5.902	118.4	149.3
44.3	4.375	5.985	118.4	151.1
44.7	4.490	6.293	122.4	159.9
44.8	4.515	6.362	122.4	161.8
44.8	4.525	6.384	122.4	162.3
45.2	4.600	6.661	125.9	170.9
44.9	4.710	6.908	127.2	176.5
44.7	4.765	7.013	127.2	178.5
44.3	4.810	7.034	127.2	177.5
44.3	4.830	7.120	127.2	180.2
43.8	4.900	7.186	127.2	180.0
43.6	4.960	7.320	128.3	182.9
42.1	5.140	7.376	127.3	178.0
41.8	5.190	7.473	127.3	179.9
41.7	5.240	7.646	127.3	184.7
41.4	5.325		128.7	
40.9	5.385		128.7	
39.2	5.650		128.7	
35.6	6.040		123.2	

Thickness = .063 inches
Yield Strength = 47.5 ksi
Specimen Width = 23.88 inches

TABLE J6
R-Curve Data Associated with Figures J1 and J3

DATA FOR SPECIMEN NO. 2
2091-T3 LONGITUDINAL SHEET

Load, kips	Half Crack Length (a), inch	Half Crack Length (a + rho), inch	Corresponding Fracture Toughness, ksi $\sqrt{\text{inch}}$	
			Not Adjusted	Adjusted for Plasticity
0	3.835	3.835	0.0	0.0
5.7	3.835	3.847	14.1	13.2
10.2	3.875	3.921	25.3	25.5
15.2	3.875	3.978	37.8	38.3
20.1	3.875	4.060	49.9	51.2
25.2	3.885	4.185	62.7	65.2
30.1	3.920	4.382	75.3	80.9
35.1	3.955	4.630	88.3	97.8
38.7	4.020	4.921	98.4	113.0
41.0	4.085	5.172	105.4	124.1
43.3	4.160	5.501	112.7	137.9
44.9	4.245	5.825	118.4	149.7
45.6	4.305	6.042	121.1	156.9
46.0	4.355	6.225	123.4	162.8
46.5	4.495	6.723	127.5	177.7
46.5	4.560	6.951	128.8	184.1
46.5	4.635	7.376	130.3	197.1
46.0	4.730		130.3	
45.3	4.885		131.9	
44.9	4.940		131.9	
44.2	5.045		131.9	
43.4	5.175		131.9	
42.3	5.325		131.9	
42.5	5.350		131.9	
41.6	5.470		131.9	
40.4	5.610		131.9	
39.3	5.800		131.9	

Thickness = .063 inches
Yield Strength = 47.5 ksi
Specimen Width = 23.87 inches

TABLE J7
R-Curve Data Associated with Figures J2 and J4

DATA FOR SPECIMEN NO. 3
2091-T3 TRANSVERSE SHEET

Load, kips	Half Crack Length (a), inch	Half Crack Length (a + rho), inch	Corresponding Fracture Toughness, ksi $\sqrt{\text{inch}}$	
			Not Adjusted	Adjusted for Plasticity
0	3.875	3.875	0.0	0.0
5.1	3.875	3.887	12.7	11.8
10.3	3.875	3.931	25.6	25.8
15.0	3.880	4.001	37.3	37.9
20.2	3.880	4.105	50.2	51.8
24.8	3.880	4.230	61.6	64.5
30.1	3.925	4.494	75.4	82.3
31.9	4.000	4.673	80.9	89.5
34.0	4.055	4.861	87.0	97.9
35.8	4.070	5.015	91.8	106.0
37.7	4.105	5.214	97.2	114.8
38.1	4.135	5.293	98.7	117.4
38.6	4.145	5.354	100.2	119.9
39.0	4.175	5.439	101.7	122.6
39.8	4.260	5.684	105.2	130.1
39.9	4.290	5.748	105.2	131.7
40.0	4.360	5.883	107.4	134.6
40.4	4.500	6.226	110.9	143.2
40.4	4.555	6.338	110.9	145.6
40.4	4.640	6.519	113.3	149.5
40.2	4.710	6.660	113.3	152.3
40.2	4.790	6.856	115.4	156.7
40.1	4.830	6.934	115.4	158.2
39.8	4.910	7.099	115.4	161.3
39.8	4.975	7.318	117.5	167.4
39.2	5.140		118.6	
38.5	5.315		118.6	
37.7	5.485		120.1	
37.5	5.625		122.0	
36.5	5.810		122.0	

Thickness = .063 inches
Yield Strength = 43.5 ksi
Specimen Width = 23.87 inches

TABLE J8

R-CURVE DATA ASSOCIATED WITH FIGURES J2 AND J4

DATA FOR SPECIMEN NO. 4

2091-T3 TRANSVERSE SHEET

Load, kips	Half Crack Length (a), inch	Half Crack Length (a + rho), inch	Corresponding Fracture Toughness, ksi $\sqrt{\text{inch}}$	
			Not Adjusted	Adjusted for Plasticity
0.0	3.845	3.845	0.0	0.0
5.1	3.845	3.857	12.6	11.8
10.4	3.845	3.901	25.7	25.9
15.3	3.880	4.006	38.0	38.7
20.0	3.895	4.116	49.8	51.3
25.1	3.895	4.256	62.5	65.5
30.1	3.915	4.481	75.2	82.1
33.7	3.985	4.751	85.2	95.5
36.2	4.105	5.092	93.3	108.4
37.4	4.145	5.246	97.0	114.4
38.1	4.245	5.459	100.4	120.1
38.8	4.350	5.717	104.0	127.5
39.2	4.430	5.900	106.4	132.2
39.4	4.565	6.170	109.2	138.1
39.4	4.625	6.282	110.2	140.4
39.4	4.755	6.571	112.4	146.9
39.4	4.815	6.701	113.5	149.8
39.3	4.900	6.905	114.6	154.4
39.1	5.030	7.226	116.3	161.6
38.3	5.260	7.896	117.9	177.0
38.3	5.320		119.0	
38.3	5.350		119.0	
38.2	5.400		120.1	
37.7	5.495		120.1	
37.6	5.605		121.9	
36.9	5.735		121.9	
35.8	5.990		122.9	
31.9	6.185		112.8	
31.9	6.575		119.7	

Thickness = .063 inches

Yield Strength = 43.5 ksi

Specimen Width = 23.88 inches

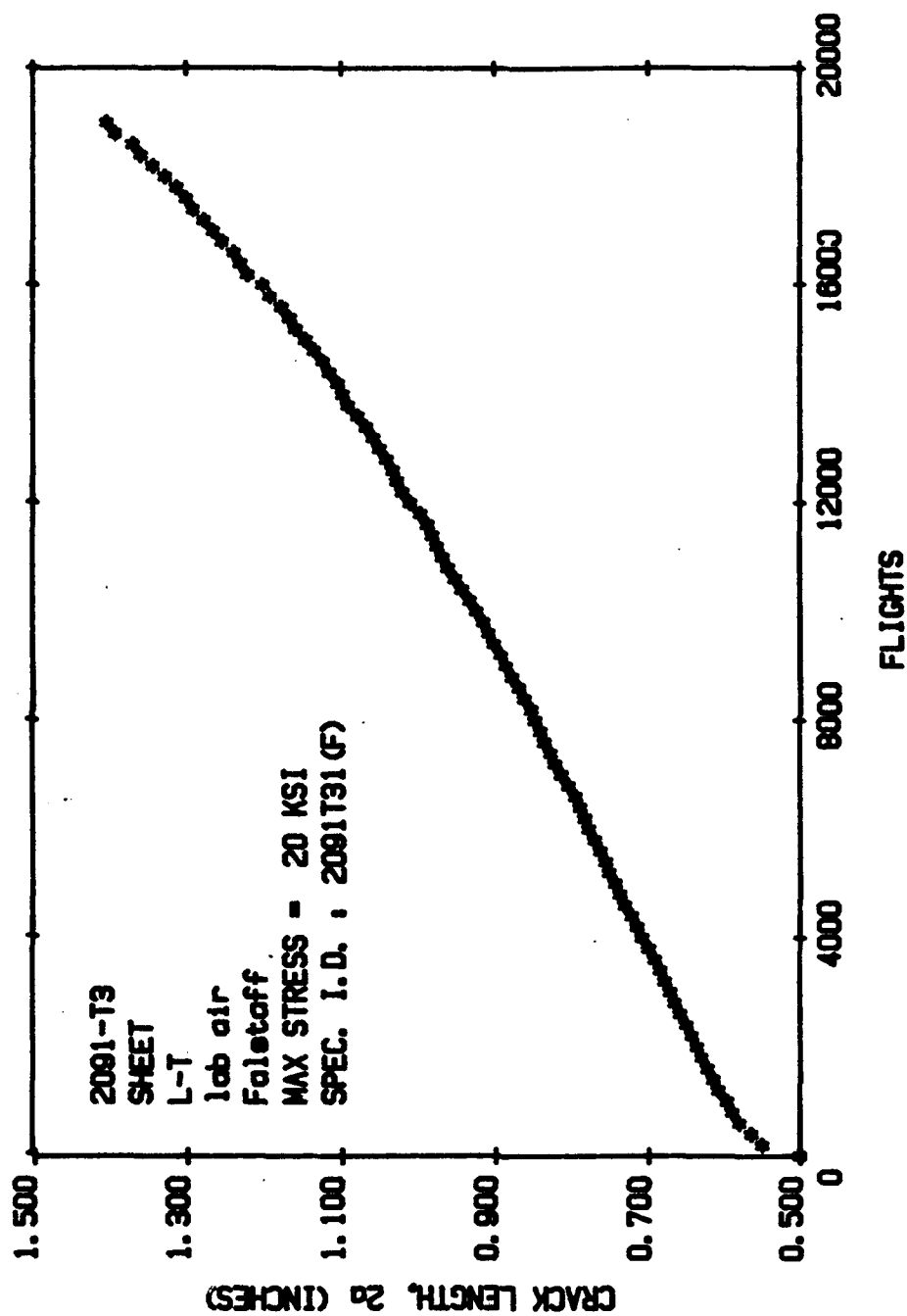


FIGURE J5. "ALSTAFF SPECTRUM
CRACK LENGTH VS FLIGHTS DATA FOR 2091-T3
0.063 INCH SHEET,
AIR FORCE.

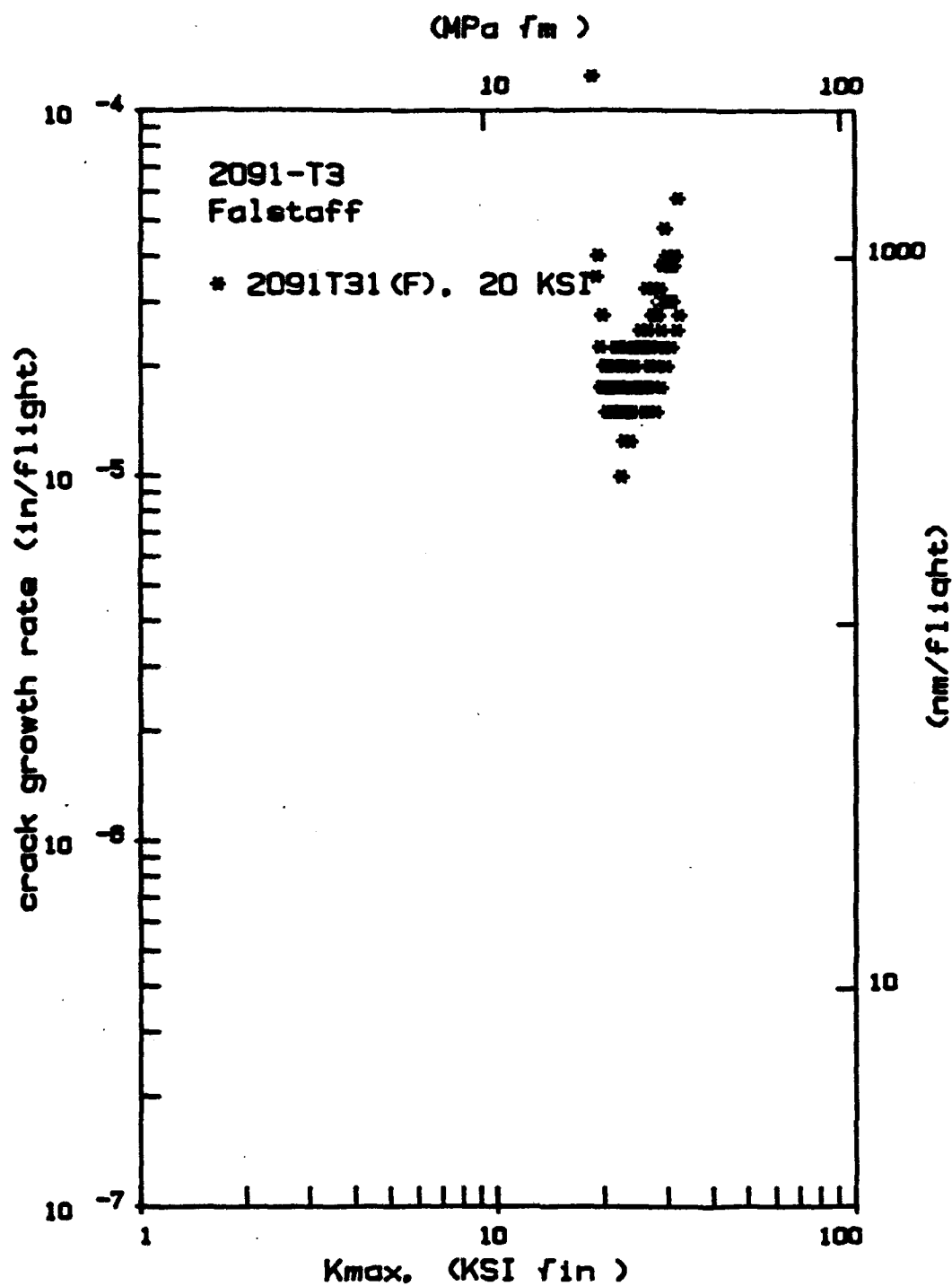


Figure J6. FALSTAFF Spectrum Crack Growth Rate
vs Kmax Data for 2091-T3
0.063 Inch Sheet.
Air Force

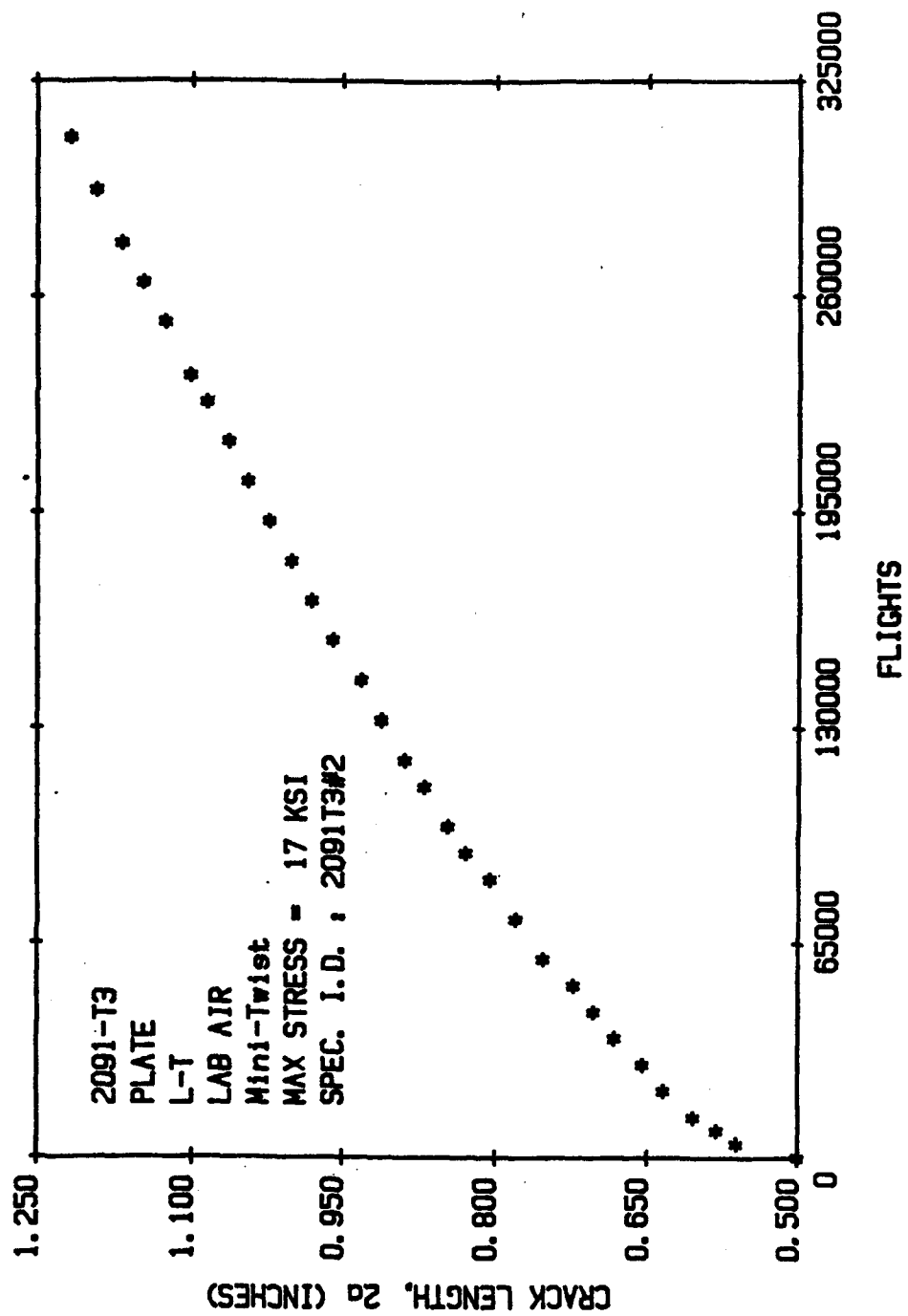


Figure J7. Mini-TWIST Spectrum Crack Length vs Flights Data for
for 2091-T3 0.063 Inch Sheet.
Air Force

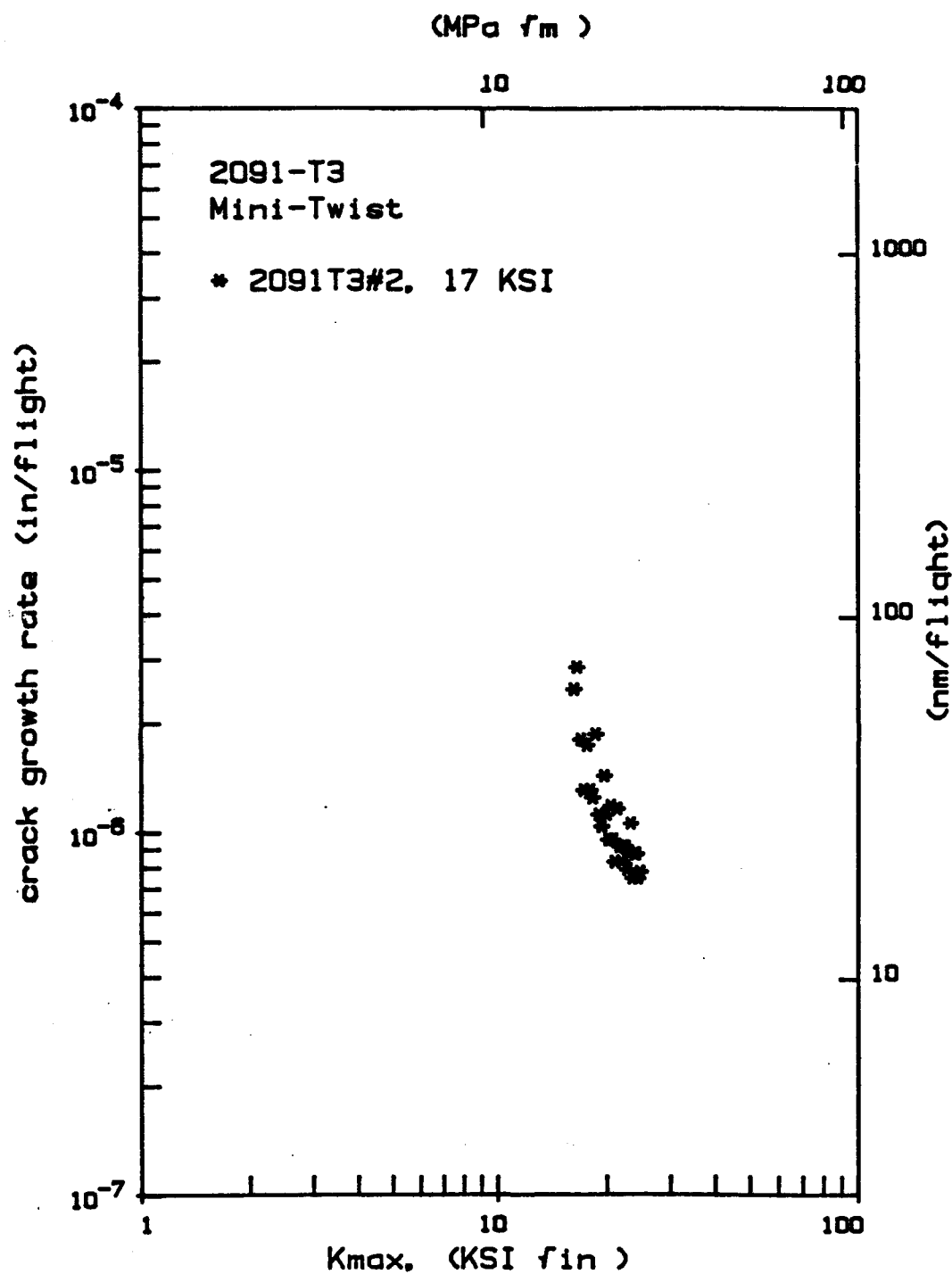


Figure J8. Mini-TWIST Spectrum Crack Growth Rate vs
 Kmax Data for 2091-T3
 0.063 Inch Sheet, Air Force

TABLE J9

TENSILE RESULTS FOR ALCOA

2091-T8 SHEET (0.063" X 48" X 48")

COMPANY	TEST TEMP (DEGREES F)	ORIENT- ATION	ULTIMATE STRENGTH (KSI)	YIELD STRENGTH (KSI)	ELONG (%)	RA (%)	E (MSI)
MCAIR	RT	LONG	62.5	50.0	22.0		5.5
			62.5	49.4	21.0		5.4
			61.5	49.2	20.0		5.9
NORTHROP	RT	LONG	65.2	53.2	21.9		11.2
			64.9	52.9	19.0		11.2
			64.9	53.1	21.9		11.2
			64.7	52.9	21.9		11.3
			AVERAGE		63.7	51.5	21.1
STANDARD DEVIATION		1.5	1.9	0.6		3.0	

TABLE J10

TENSILE RESULTS FOR ALCOA

2091-T8 SHEET (0.063" X 48" X 48")

COMPANY	TEST TEMP (DEGREES F)	ORIENT- ATION	ULTIMATE STRENGTH (KSI)	YIELD STRENGTH (KSI)	ELONG (%)	RA (%)	E (MSI)
MCAIR	RT	45 DEG	62.0	38.0	24.0		6.0
			62.0	38.5	25.0		5.9
			62.5	38.0	22.0		6.7
NORTHROP	RT	45 DEG	64.3	43.9	16.9		11.0
			63.4	43.8	14.1		11.0
			64.1	43.9	17.2		11.2
			63.8	43.1	16.7		11.0
		AVERAGE	63.2	41.3	19.4		9.0
	STANDARD DEVIATION		1.0	3.0	4.2		2.6

TABLE J11

TENSILE RESULTS FOR ALCOA

2091-T8 SHEET (0.063" X 48" X 48")

COMPANY	TEST TEMP (DEGREES F)	ORIENT- ATION	ULTIMATE STRENGTH (KSI)	YIELD STRENGTH (KSI)	ELONG (%)	RA (%)	E (MSI)
MCAIR	RT	L TRANS	64.5	40.9	18.0		5.6
			65.0	43.6	16.0		5.9
			66.0	42.3	21.0		5.5
NORTHROP	RT	L TRANS	67.9	47.7	20.8		11.3
			68.2	47.4	18.2		11.3
			67.5	47.7	16.9		11.2
			68.3	47.2	18.7		11.1
		AVERAGE	65.2	42.3	18.3		5.7
		STANDARD DEVIATION	0.8	1.4	2.5		0.2

E J12

COMPRESSION RESULTS FOR ALCOA

2091-T8 SHEET (0.063" X 48" X 48")

COMPANY	TEST TEMPERATURE (DEGREES F)	ORIENTATION	COMPRESSIVE YIELD STRENGTH (KSI)	COMPRESSIVE MODULUS (KSI)
MCAIR	RT	LONG		12.5 11.5
NORTHROP	RT	LONG	41.7 42.2 41.7	11.5 11.2 12.1
		AVERAGE	41.9	11.8
		STANDARD DEVIATION	0.3	0.5

TABLE J13

COMPRESSION RESULTS FOR ALCOA

2091-T8 SHEET (0.063" X 48" X 48")

COMPANY	TEST TEMPERATURE (DEGREES F)	ORIENTATION	COMPRESSIVE YIELD STRENGTH (KSI)	COMPRESSIVE MODULUS (KSI)
MCAIR	RT	45 DEG		12.1 12.2 11.7
		AVERAGE		12.0
		STANDARD DEVIATION		0.3

TABLE J14

COMPRESSION RESULTS FOR ALCOA

2091-T8 SHEET (0.063" X 48" X 48")

COMPANY	TEST TEMPERATURE (DEGREES F)	ORIENTATION	COMPRESSIVE YIELD STRENGTH (KSI)	COMPRESSIVE MODULUS (KSI)
MCAIR	RT	L TRANS		12.6 12.6 12.5
NORTHROP	RT	L TRANS	46.4 48.8 48.9	12.1 11.9 12.0
		AVERAGE	48.7	12.3
		STANDARD DEVIATION	0.3	0.3

TABLE J15
SLOTTED SHEAR RESULTS FOR ALCOA
2091-T8 SHEET (0.063" X 48" X 48")

COMPANY	ORIENTATION	SHEAR STRENGTH (KSI)
MCAIR	LONG	44.8
		46.8
NORTHROP	LONG	43.9
		43.8
		43.7
	AVERAGE	44.6
	STANDARD DEVIATION	1.3

TABLE J16
SLOTTED SHEAR RESULTS FOR ALCOA
2091-T8 SHEET (0.063" X 48" X 48")

COMPANY	ORIENTATION	SHEAR STRENGTH (KSI)
NORTHROP	L TRANS	44.7
		45.0
		44.6
	AVERAGE	44.8
	STANDARD DEVIATION	0.2

TABLE J17

BEARING RESULTS FOR ALCOA

2091-T8 SHEET (0.063" X 48" X 48")

COMPANY	ORIENTATION	e/D	BEARING		BEARING	
			ULT.	STR.	YIELD	STR.
			(KSI)		(KSI)	
MCAIR	LONG	1.5		96.1		
				98.9		83.5
				99.2		83.9
NORTHROP	LONG	1.5		101.6		71.1
				100.7		69.7
				101.7		72.2
AVERAGE				99.7		76.1
STANDARD DEVIATION				2.1		7.0

TABLE J18

BEARING RESULTS FOR ALCOA

2091-T8 SHEET (0.063" X 48" X 48")

COMPANY	ORIENTATION	e/D	BEARING		BEARING	
			ULT.	STR.	YIELD	STR.
			(KSI)		(KSI)	
MCAIR	L TRANS	1.5		98.2		85.7
				97.4		84.0
				97.5		85.1
NORTHROP	L TRANS	1.5		104.4		76.9
				103.7		73.9
				104.0		75.4
AVERAGE				100.9		80.2
STANDARD DEVIATION				3.5		5.3

TABLE J19

BEARING RESULTS FOR ALCOA

2091-T8 SHEET (0.063" X 48" X 48")

COMPANY	ORIENTATION	e/D	BEARING		BEARING	
			ULT.	STR.	YIELD	STR.
			(KSI)		(KSI)	
MCAIR	LONG	2.0		128.6		107.0
				130.3		108.4
				127.1		107.0
NORTHROP	LONG	2.0		127.3		72.8
				129.9		76.0
				130.2		74.7
AVERAGE				128.9		91.0
STANDARD DEVIATION				1.5		18.1

TABLE J20

BEARING RESULTS FOR ALCOA

2091-T8 SHEET (0.063" X 48" X 48")

COMPANY	ORIENTATION	e/D	BEARING		BEARING	
			ULT.	STR.	YIELD	STR.
			(KSI)		(KSI)	
MCAIR	L TRANS	2.0		131.2		110.7
				130.6		109.5
				128.3		107.0
NORTHROP	L TRANS	2.0		130.4		85.2
				129.7		85.0
				129.0		88.2
AVERAGE				129.9		97.6
STANDARD DEVIATION				1.1		12.7

TABLE J21
R-CURVE FRACTURE TOUGHNESS
RESULTS FOR 2091-T8X SHEET
(0.063" X 48" X 48")
Northrop

Specimen ID	Orientation	Kc
VIRLI	L-T	130.0

TABLE J22

R-CURVE FRACTURE TOUGHNESS RESULTS

For 2091-T8 Sheet (0.063" x 48" x 48")

MCDONNELL AIRCRAFT CO

SPECIMEN IDENTIFICATION: LT1
 MATERIAL DESCRIPTION: 2091 AL-LI SHEET
 SPECIMEN TYPE: C(T) (COMPACT SPECIMEN)
 SPECIMEN ORIENTATION: L-T
 YIELD STRENGTH: 49.5 KSI
 SPECIMEN THICKNESS: 0.063 IN
 SPECIMEN WIDTH: 3.999 IN

SPECIMEN IS INVALID PER ASTM E561-86, PARA. 7.5

APPLIED LOAD (lbs)	PHYSICAL CRACK LENGTH (in)	Kr (UNCORRECTED) (psi $\sqrt{in}$)	EFFECTIVE CRACK LENGTH (in)	Kr (CORRECTED) (psi $\sqrt{in}$)
800	1.485	42,884	1.629	47,141
975	1.500	52,765	1.753	62,495
1,025	1.507	55,716	1.810	68,349
1,100	1.516	60,171	1.935	80,342
1,150	1.523	63,194	***	***
1,175	1.529	64,829	***	***
1,200	1.534	66,420	***	***
1,225	1.545	68,270	***	***
1,250	1.555	70,121	***	***
1,275	FAILURE	---	---	---

*** Indicates that the equation for Kr (Corrected) did not converge to a solution.

TABLE J23

R-CURVE FRACTURE TOUGHNESS RESULTS

For 2091-T8 Sheet (0.063" x 48" x 48")

MCDONNELL AIRCRAFT CO

SPECIMEN IDENTIFICATION: LT2
 MATERIAL DESCRIPTION: 2091 AL-LI SHEET
 SPECIMEN TYPE: C(T) (COMPACT SPECIMEN)
 SPECIMEN ORIENTATION: L-T
 YIELD STRENGTH: 49.5 KSI
 SPECIMEN THICKNESS: 0.064 IN
 SPECIMEN WIDTH: 4.002 IN

SPECIMEN IS INVALID PER ASTM E561-86, PARA. 7.5

APPLIED LOAD (lbs)	PHYSICAL CRACK LENGTH (in)	Kr (UNCORRECTED) (psi √in)	EFFECTIVE CRACK LENGTH (in)	Kr (CORRECTED) (psi √in)
975	1.501	51,927	1.743	60,983
1,000	1.515	53,727	1.783	64,343
1,050	1.523	56,711	1.847	70,665
1,110	1.526	60,073	1.943	80,115
1,160	1.530	62,951	***	***
1,190	1.534	64,769	***	***
1,220	1.540	66,640	***	***
1,235	1.543	67,574	***	***
1,270	1.549	69,785	***	***
1,285	1.570	71,568	***	***
1,305	1.576	72,983	***	***
1,315	1.585	73,989	***	***
1,325	1.592	74,876	***	***
1,335	1.598	75,731	***	***
1,340	1.605	76,397	***	***
1,345	FAILURE	---	---	---

*** Indicates that the equation for Kr (Corrected) did not converge to a solution.

TABLE J24

R-CURVE FRACTURE TOUGHNESS RESULTS

For 2091-T8 Sheet (0.063" x 48" x 48")

MCDONNELL AIRCRAFT CO

SPECIMEN IDENTIFICATION: TL1
 MATERIAL DESCRIPTION: 2091 AL-LI SHEET
 SPECIMEN TYPE: C(T) (COMPACT SPECIMEN)
 SPECIMEN ORIENTATION: T-L
 YIELD STRENGTH: 42.3 KSI
 SPECIMEN THICKNESS: 0.064 IN
 SPECIMEN WIDTH: 3.998 IN

SPECIMEN IS INVALID PER ASTM E561-86, PARA. 7.5

APPLIED LOAD (lbs)	PHYSICAL CRACK LENGTH (in)	Kr (UNCORRECTED) (psi /in)	EFFECTIVE CRACK LENGTH (in)	Kr (CORRECTED) (psi /in)
800	1.495	42,504	1.708	48,955
825	1.499	43,946	1.734	51,378
1,025	1.503	54,749	***	***
1,050	1.509	56,296	***	***
1,085	1.513	58,335	***	***
1,095	1.518	59,045	***	***
1,135	1.524	61,462	***	***
1,165	1.535	63,532	***	***
1,175	1.544	64,468	***	***
1,190	1.544	65,291	***	***
1,215	1.549	66,881	***	***
1,230	1.557	68,045	***	***
1,240	1.562	68,819	***	***
1,250	1.583	70,357	***	***
1,270	1.587	71,638	***	***
1,280	1.594	72,565	***	***
1,290	1.612	73,989	***	***
1,295	1.616	74,493	***	***
1,305	FAILURE	---	---	---

*** Indicates that the equation for Kr (Corrected) did not converge to a solution.

TABLE J25

R-CURVE FRACTURE TOUGHNESS RESULTS

For 2091-T8 Sheet (0.063" x 48" x 48")

MCDONNELL AIRCRAFT CO

SPECIMEN IDENTIFICATION: TL2
MATERIAL DESCRIPTION: 2091 AL-LI SHEET
SPECIMEN TYPE: C(T) (COMPACT SPECIMEN)
SPECIMEN ORIENTATION: T-L
YIELD STRENGTH: 42.3 KSI
SPECIMEN THICKNESS: 0.061 IN
SPECIMEN WIDTH: 3.999 IN

SPECIMEN IS INVALID PER ASTM E561-86, PARA. 7.5

APPLIED LOAD (lbs)	PHYSICAL CRACK LENGTH (in)	Kr (UNCORRECTED) (psi /in)	EFFECTIVE CRACK LENGTH (in)	Kr (CORRECTED) (psi /in)
950	1.507	53,350	2.062	79,002
975	1.511	54,882	***	***
1,075	1.517	60,775	***	***
1,120	1.522	63,517	***	***
1,130	1.526	64,248	***	***
1,180	1.531	67,305	***	***
1,240	1.541	71,181	***	***
1,255	1.544	72,179	***	***
1,265	1.550	73,059	***	***
1,280	1.569	74,867	***	***
1,285	1.576	75,466	***	***
1,295	FAILURE	---	---	---

*** Indicates that the equation for Kr (Corrected) did not converge to a solution.

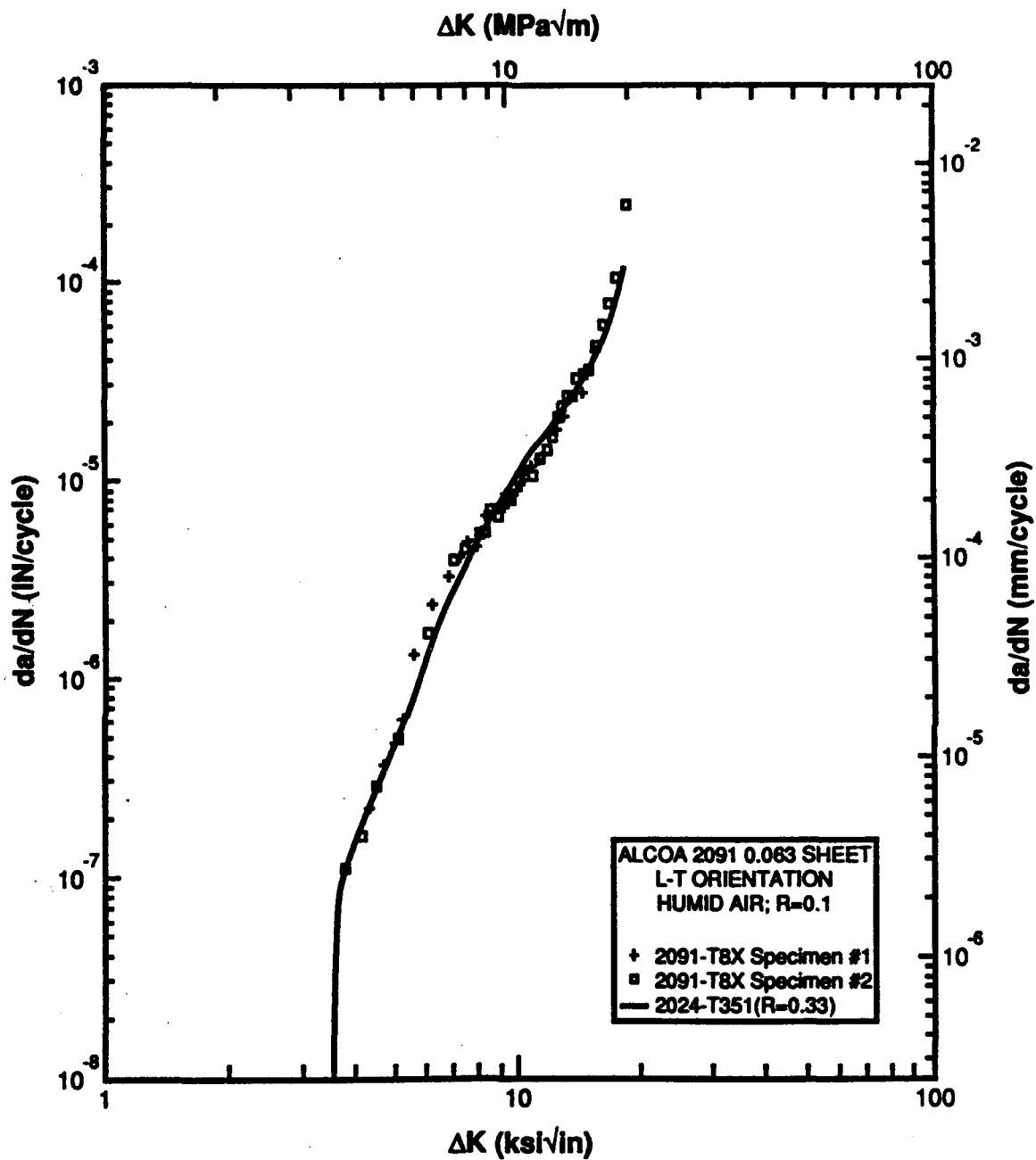


FIGURE J9. FATIGUE CRACK GROWTH RATE DATA for 2091-T8X 0.063 Inch Sheet Relative to 2024-T351 (L-T Orientation). Northrop.

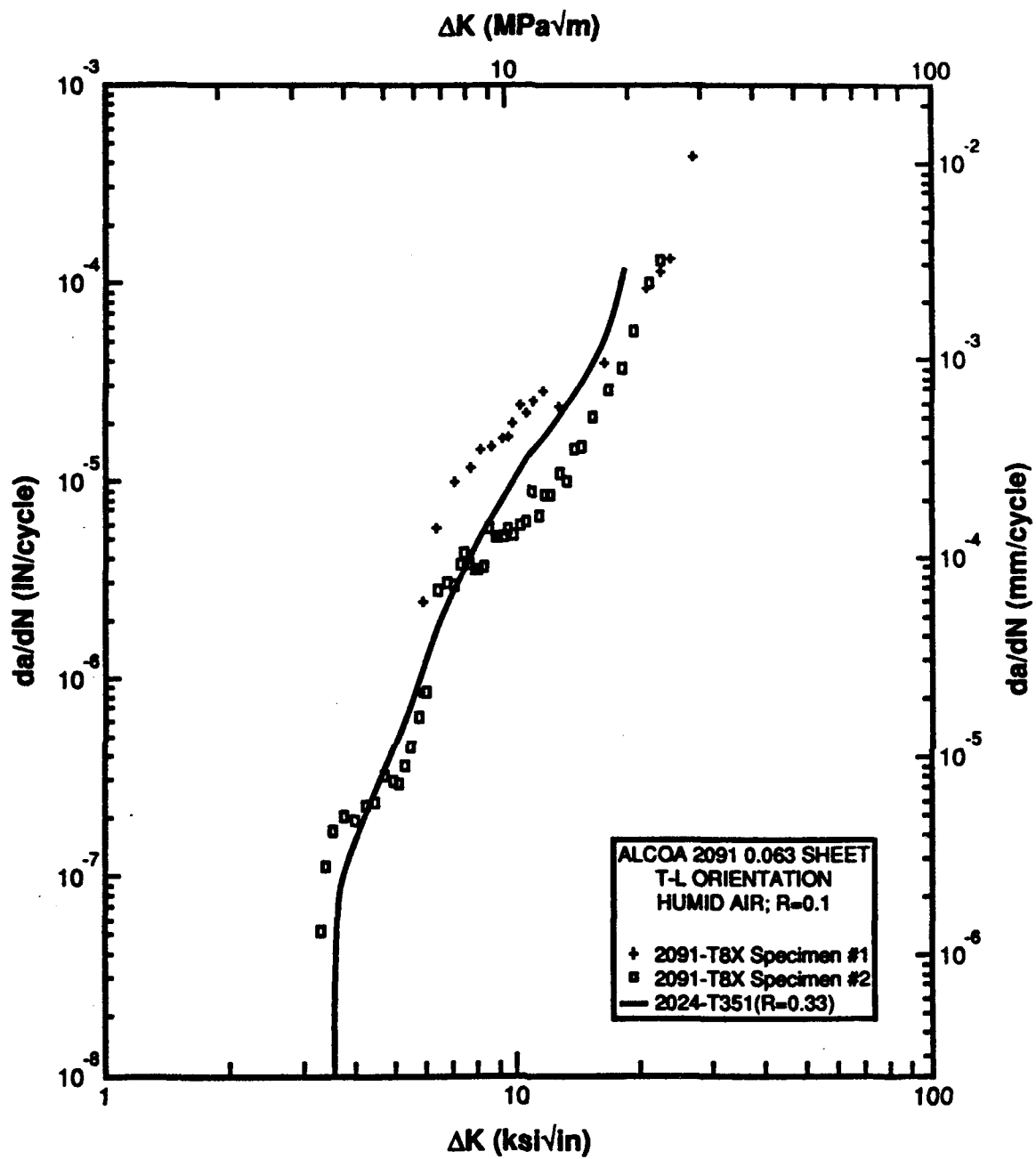


FIGURE J10. FATIGUE CRACK GROWTH RATE DATA for
 2091-T8X 0.063 Inch Sheet Relative
 to 2024-T351 (T-L Orientation).
 Northrop.

TABLE J26
FATIGUE CRACK GROWTH RATE DATA ASSOCIATED
WITH FIGURE J9

CRACK GROWTH TEST OF ALCOA 2091 .063" SHT SPEC V1FL1
M(T) SPECIMEN TYPE L-T ORIENTATION
TEMP = R.T. REL HUM = 95 % 22-AUG-89
W = 2.999 IN B = .0612 IN R = .1
FREQUENCY = 10 HZ H.A. ENVIRONMENT
GRID SPACING = .05 IN FILE CODE: RK1:C00152.DDN
YIELD STRESS = 53 KSI FITO CODE: RK1:C00152.DFO

SPECIMEN V1FL1				M(T) SPECIMEN TYPE			
REF #	K-MAX	2A IN	2A/W	K-BAR	DELTA K-BAR	DA/DN IN/CYC	VALID PER ASTM
1	4.74	.4671	.1558				
2	4.95	.5078	.1693	4.85	4.36	2.26389E-07	Y
3	5.48	.6106	.2036	5.22	4.7	3.72283E-07	Y
4	5.72	.6606	.2203	5.6	5.04	4.90196E-07	Y
5	5.95	.7083	.2362	5.84	5.25	6.28289E-07	Y
6	6.52	.8266	.2756	6.24	5.61	1.37500E-06	Y
7	7.21	.9731	.3245	6.86	6.18	2.44167E-06	Y
8	7.86	1.1081	.3695	7.53	6.78	3.37500E-06	Y
9	8.27	1.1906	.397	8.06	7.26	4.12500E-06	Y
10	8.53	1.2411	.4138	8.4	7.56	5.05000E-06	Y
11	9.04	1.3381	.4462	8.78	7.9	4.85000E-06	Y
12	9.4	1.4051	.4685	9.22	8.3	6.69999E-06	Y
13	9.71	1.4586	.4864	9.55	8.6	6.68749E-06	Y
14	10.04	1.5161	.5055	9.87	8.89	7.18752E-06	Y
15	10.41	1.5766	.5257	10.23	9.2	7.56250E-06	Y
16	10.85	1.6438	.5481	10.63	9.56	8.40624E-06	Y
17	11.21	1.6981	.5662	11.03	9.92	9.04167E-06	Y
18	11.49	1.7376	.5794	11.35	10.22	9.87500E-06	Y
				11.66	10.49	1.13750E-05	Y

TABLE J26 CONTINUED

SPECIMEN VI FL1				M(T) SPECIMEN TYPE			
REF #	K-MAX	2A IN	2A/W	K-BAR	DELTA K-BAR	DA/DN IN/CYC	VALID PER ASTM
19	11.82	1.7831	.5946				
20	12.2	1.8321	.6109	12.01	10.81	1.22500E-05	Y
21	12.62	1.8841	.6282	12.41	11.17	1.30000E-05	Y
22	13.1	1.9396	.6467	12.86	11.57	1.38750E-05	Y
23	13.58	1.9916	.6641	13.34	12.01	1.73333E-05	Y
24	14.12	2.0461	.6823	13.85	12.46	1.81667E-05	Y
25	14.57	2.0893	.6967	14.34	12.91	2.16249E-05	Y
26	15.18	2.1423	.7144	14.87	13.38	2.65000E-05	Y
27	16.89	2.2726	.7578	16	14.4	2.83153E-05	Y
28	17.73	2.3261	.7756	17.3	15.57	4.45833E-05	Y

TABLE J27
FATIGUE CRACK GROWTH RATE DATA ASSOCIATED
WITH FIGURE J9

CRACK GROWTH TEST OF ALCOA 2091 .063" SHT SPEC V1FL3
M(T) SPECIMEN TYPE L-T ORIENTATION
TEMP = R.T. REL HUM = 95 % 28-AUG-89
W = 2.999 IN B = .0612 IN R = .1
FREQUENCY = 10 HZ H.A. ENVIRONMENT
GRID SPACING = .05 IN FILE CODE: RK1:C00154.DDN
YIELD STRESS = 65 KSI FITO CODE: RK1:C00154.DF0

SPECIMEN V1FL3				M(T) SPECIMEN TYPE			
REF #	K-MAX	2A IN	2A/W	K-BAR	DELTA K-BAR	DA/DN IN/CYC	VALID PER ASTM
1	3.87	.1891	.0631				
2	4.51	.2556	.0852	4.2	3.78	1.14655E-07	Y
3	4.63	.2688	.0896	4.57	4.11	1.65625E-07	Y
4	5.38	.3606	.1202	5.01	4.51	2.99837E-07	Y
5	5.96	.4391	.1464	5.67	5.11	5.09740E-07	Y
6	7.34	.6453	.2152	6.67	6	1.71875E-06	Y
7	8.1	.7668	.2557	7.72	6.95	4.05000E-06	Y
8	8.39	.8131	.2711	8.25	7.42	4.62500E-06	Y
9	8.68	.8606	.287	8.53	7.68	4.75000E-06	Y
10	9.02	.9156	.3053	8.85	7.96	5.49999E-06	Y
11	9.37	.9721	.3241	9.19	8.27	5.65000E-06	Y
12	9.73	1.0301	.3435	9.55	8.59	7.25000E-06	Y
13	10.06	1.0838	.3614	9.9	8.91	6.71875E-06	Y
14	10.48	1.1483	.3829	10.27	9.24	8.06250E-06	Y
15	10.91	1.2141	.4048	10.69	9.62	8.21875E-06	Y
16	11.32	1.2761	.4255	11.11	10	1.03333E-05	Y
17	11.76	1.3401	.4468	11.54	10.38	1.06667E-05	Y
18	12.22	1.4046	.4684	11.99	10.79	1.07500E-05	Y
				12.52	11.27	1.35000E-05	Y

TABLE J27 CONTINUED

SPECIMEN VIFL3				N(T) SPECIMEN TYPE			
REF #	K-MAX	2A IN	2A/W	K-BAR	DELTA K-BAR	DA/DN IN/CYC	VALID PER ASTM
19	12.82	1.4856	.4954				
20	13.28	1.5441	.5149	13.05	11.74	1.46250E-05	Y
21	13.67	1.5926	.531	13.47	12.12	1.73215E-05	Y
22	14.06	1.6396	.5467	13.86	12.48	2.13637E-05	Y
23	14.45	1.6836	.5614	14.25	12.83	2.44444E-05	Y
24	14.82	1.7251	.5752	14.63	13.17	2.76667E-05	Y
25	15.16	1.7611	.5872	14.99	13.49	2.72727E-05	Y
26	15.58	1.8046	.6017	15.37	13.83	3.29545E-05	Y
27	16.2	1.8641	.6216	15.89	14.3	3.45930E-05	Y
28	16.83	1.9221	.6409	16.51	14.86	3.62500E-05	Y
29	17.51	1.9796	.6601	17.17	15.45	4.79167E-05	Y
30	18.23	2.0366	.6791	17.86	16.08	6.33334E-05	Y
31	18.9	2.0861	.6956	18.56	16.71	7.98387E-05	Y
32	19.69	2.1401	.7136	19.29	17.36	1.08000E-04	Y
33	21.11	2.2266	.7424	20.39	18.35	2.47143E-04	Y

TABLE J28
FATIGUE CRACK GROWTH RATE DATA ASSOCIATED
WITH FIGURE J10

CRACK GROWTH TEST OF ALCOA 2091 .063" SHT SPEC V1FT1
M(T) SPECIMEN TYPE T-L ORIENTATION
TEMP = R.T. REL HUM = 95 % 2-AUG-89
W = 2.999 IN B = .061 IN R = .1
FREQUENCY = 10 HZ H.A. ENVIRONMENT
GRID SPACING = .05 IN FILE CODE: RK1:C00149.DDN
YIELD STRESS = 47.7 KSI FITO CODE: RK1:C00149.DF0

SPECIMEN V1FT1				M(T) SPECIMEN TYPE			
REF #	K-MAX	2A IN	2A/W	K-BAR	DELTA K-BAR	DA/DN IN/CYC	VALID PER ASTM
1	6.17	.8944	.2982				
2	6.21	.903	.3011	6.19	5.57	7.20342E-08	Y
3	6.39	.9457	.3153	6.3	5.67	3.03622E-07	Y
4	7.01	1.0875	.3626	6.7	6.03	9.37501E-07	Y
5	7.78	1.2589	.4198	7.39	6.65	1.94886E-06	Y
6	8.25	1.3559	.4521	8.01	7.21	2.42500E-06	Y
7	8.56	1.4197	.4734	8.4	7.56	3.18750E-06	Y
8	9.25	1.5502	.5169	8.9	8.01	3.32908E-06	Y
9	9.53	1.5987	.5331	9.39	8.45	3.78907E-06	Y
10	9.78	1.6412	.5472	9.65	8.69	3.93519E-06	Y
11	10.25	1.7185	.573	10.01	9.01	4.76852E-06	Y
12	10.54	1.7632	.5879	10.4	9.36	6.58086E-06	Y
13	10.77	1.7964	.599	10.66	9.59	5.73277E-06	Y
14	11.25	1.8644	.6217	11.01	9.91	6.93877E-06	Y
15	11.95	1.9542	.6516	11.59	10.44	8.15909E-06	Y
16	13.11	2.0847	.6951	12.52	11.26	6.33494E-06	Y
17	19.27	2.5042	.835	15.77	14.19	1.27121E-05	Y
18	20.25	2.5444	.8484	19.75	17.78	4.02498E-05	Y
19	21.68	2.5952	.8654	20.95	18.85	5.07503E-05	Y
20	22.91	2.6327	.8779	22.28	20.05	6.24998E-05	Y
21	26.87	2.7242	.9084	24.75	22.28	3.05000E-04	Y

TABLE J29
FATIGUE CRACK GROWTH RATE DATA ASSOCIATED
with FIGURE J10

CRACK GROWTH TEST OF ALCOA 2091 .063" SHT SPEC V1FT3
M(T) SPECIMEN TYPE T-L ORIENTATION
TEMP = R.T. REL HUM = 95 % 07-SEP-89
W = 2.999 IN B = .0612 IN R = .1
FREQUENCY = 10 HZ HUMID AIR ENVIRONMENT
GRID SPACING = .05 IN FILE CODE: RK1:C00156.DDN
YIELD STRESS = 65 KSI FITO CODE: RK1:C00156.DF0

SPECIMEN V1FT3				M(T) SPECIMEN TYPE			
REF #	K-MAX	2A IN	2A/W	K-BAR	DELTA K-BAR	DA/DN IN/CYC	VALID PER ASTM
1	3.65	.2825	.0942				
2	3.72	.2935	.0979	3.69	3.32	5.49999E-08	Y
3	3.87	.3172	.1058	3.8	3.42	1.18750E-07	Y
4	4.09	.353	.1177	3.98	3.59	1.78750E-07	Y
5	4.34	.396	.132	4.22	3.8	2.15000E-07	Y
6	4.62	.4457	.1486	4.48	4.04	1.99000E-07	Y
7	4.88	.4935	.1646	4.75	4.28	2.38750E-07	Y
8	5.15	.545	.1817	5.01	4.51	2.57500E-07	Y
9	5.43	.6005	.2002	5.29	4.76	3.46875E-07	Y
10	5.63	.6415	.2139	5.53	4.98	3.20313E-07	Y
11	5.8	.677	.2257	5.72	5.14	3.16964E-07	Y
12	5.97	.7115	.2372	5.89	5.3	3.83333E-07	Y
13	6.19	.758	.2528	6.08	5.47	4.65000E-07	Y
14	6.51	.825	.2751	6.35	5.71	6.69999E-07	Y
15	6.77	.8795	.2933	6.64	5.97	9.08335E-07	Y
16	7.35	1.0025	.3343	7.06	6.35	2.92857E-06	Y
17	7.66	1.0675	.356	7.51	6.76	3.25000E-06	Y
18	7.89	1.1135	.3713	7.77	7	3.23943E-06	Y
19	8.12	1.16	.3868	8	7.2	4.00862E-06	Y
20	8.33	1.2025	.401	8.22	7.4	4.52128E-06	Y
21	8.58	1.2515	.4173	8.45	7.61	4.08335E-06	Y
22	8.82	1.298	.4328	8.7	7.83	3.87499E-06	Y
				8.92	8.03	3.80001E-06	Y

TABLE J29 CONTINUED

SPECIMEN VIFTS				H(T) SPECIMEN TYPE			
REF #	K-MAX	2A IN	2A/W	K-BAR	DELTA K-BAR	DA/DN IN/CYC	VALID PER ASTM
23	9.02	1.336	.4453				
24	9.31	1.388	.4628	9.16	8.25	3.93940E-06	Y
25	9.64	1.4475	.4827	9.47	8.53	6.19790E-06	Y
26	9.86	1.486	.4955	9.75	8.78	5.50001E-06	Y
27	10.12	1.529	.5098	9.99	8.99	5.37500E-06	Y
28	10.43	1.579	.5265	10.27	9.25	5.55555E-06	Y
29	10.71	1.6235	.5413	10.57	9.51	6.18055E-06	Y
30	11.09	1.681	.5605	10.9	9.81	5.74999E-06	Y
31	11.46	1.734	.5782	11.28	10.15	6.62501E-06	Y
32	11.87	1.7885	.5964	11.66	10.5	6.81250E-06	Y
33	12.3	1.8445	.615	12.08	10.87	9.33333E-06	Y
34	12.72	1.895	.6319	12.51	11.26	7.21429E-06	Y
35	13.19	1.949	.6499	12.95	11.65	8.99998E-06	Y
36	13.7	2.0035	.6681	13.44	12.09	9.08333E-06	Y
37	14.39	2.072	.6909	14.04	12.63	1.14167E-05	Y
38	14.85	2.1145	.7051	14.62	13.16	1.06250E-05	Y
39	15.58	2.176	.7256	15.21	13.69	1.53750E-05	Y
40	16.43	2.2405	.7471	16	14.4	1.61250E-05	Y
41	17.71	2.325	.7753	17.05	15.35	2.22369E-05	Y
42	19.16	2.406	.8023	18.41	16.57	3.11539E-05	Y
43	20.57	2.472	.8243	19.84	17.86	3.88235E-05	Y
44	22.12	2.5335	.8448	21.32	19.19	6.14998E-05	Y
45	24.14	2.599	.8666	23.09	20.78	1.09167E-04	Y
46	25.66	2.64	.8803	24.88	22.39	1.36666E-04	Y

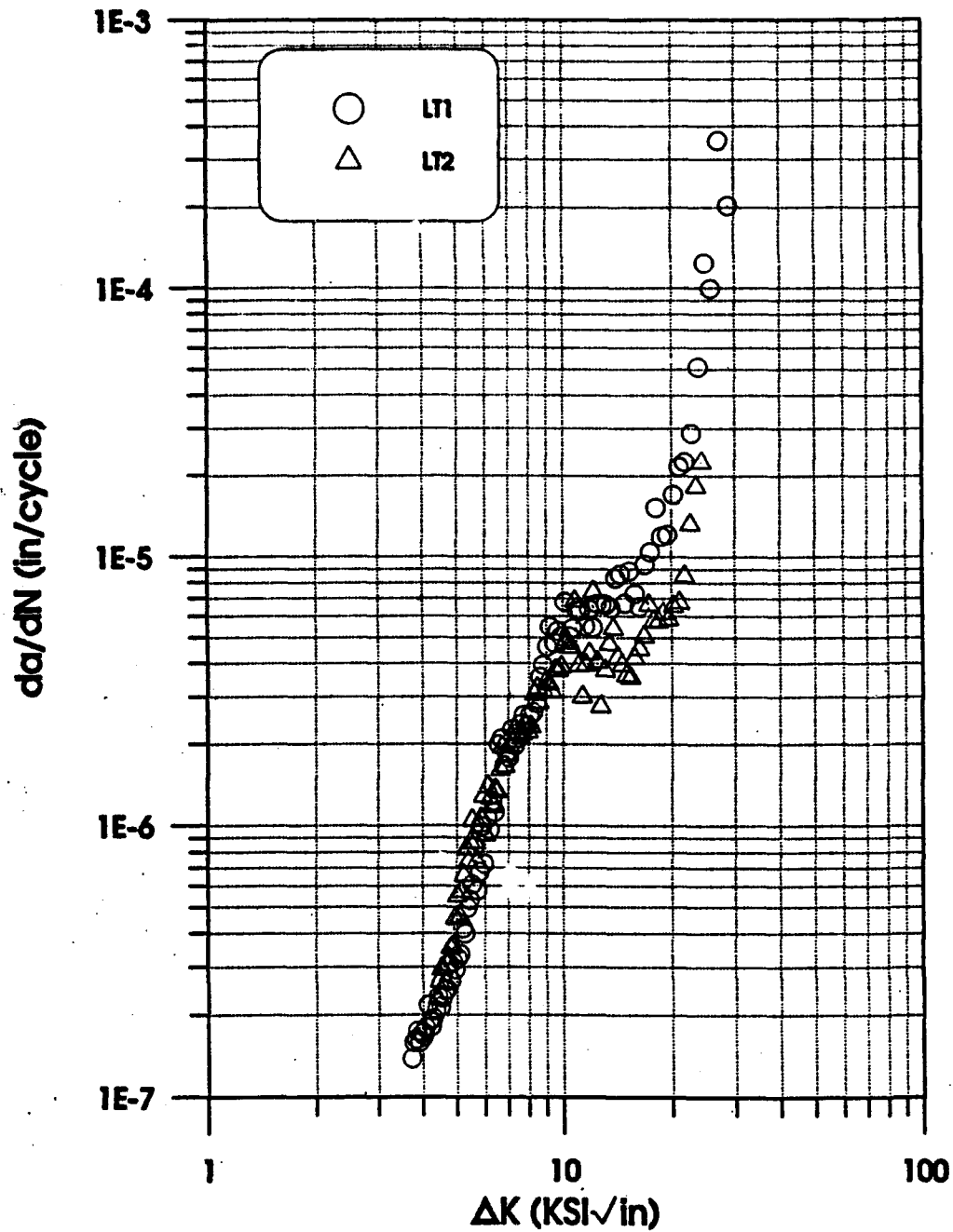


Figure J11 Figure Crack Growth Rate Data for
2091-T8 0.063 Inch Sheet. (L-T Orientation, $R=0.33$,
Lab Air and 75°F).
McDonnell Aircraft Company.

TABLE J30

Fatigue Crack Growth Rate Data Associated with Figure J11 (Specimen LT1)

TR NUMBER: TR 515-450
 ALLOY: AL2091-T8
 COMMENT: ALCOA MATERIAL
 FTU: 62.2 KSI FTY: 49.5 KSI ULT STRAIN: 0.000 E: 5600 KSI NU: 0.300 ELON: 21.0% RED A: 0.0%
 LOC IN STOCK: UN SPEC THICKNESS: 0.062 IN WIDTH: 4.000 IN MAX TEST LOAD: 0.100 KIPS DATA FILE: AL-31
 FORM: 0.063 SHEET ORIENT: L-LT R-RATIO: 0.330 ENVIR: LA TEMP: 75F FREQ: VAR
 SPECIMEN TYPE: C(T) GROUP: M2P DATE: 1-MAY-90

CRACK LENGTH--A (INCH)			DELTA CYCLES	TOTAL CYCLES	DELTA K (KSI IN ^{1/2})	AVERAGE DELTA K (KSI IN ^{1/2})	DA/DN (INCH/CYCLE)
FRONT	BACK	AVERAGE					
1.520	1.483	1.502 *	150000	0	3.69	3.71	1.39E-07
1.535	1.510	1.522 *	110000	150000	3.74	3.76	1.59E-07
1.551	1.529	1.540 *	120000	260000	3.78	3.81	1.63E-07
1.570	1.549	1.559 *	115000	495000	3.88	3.85	1.75E-07
1.588	1.571	1.580 *	115000	620000	3.93	3.91	1.59E-07
1.608	1.591	1.600 *	115000	735000	3.98	3.96	1.71E-07
1.630	1.609	1.619 *	135000	870000	4.04	4.01	1.67E-07
1.655	1.628	1.642 *	100000	970000	4.09	4.07	1.89E-07
1.670	1.650	1.660 *	90000	1060000	4.15	4.12	2.10E-07
1.691	1.668	1.679 *	110000	1170000	4.20	4.18	1.82E-07
1.707	1.692	1.699 *	110000	1280000	4.26	4.23	1.82E-07
1.726	1.713	1.719 *	105000	1385000	4.32	4.29	1.94E-07
1.748	1.732	1.740 *	95000	1480000	4.38	4.35	2.08E-07
1.766	1.753	1.760 *	85000	1575000	4.45	4.41	2.33E-07
1.790	1.773	1.782 *	85000	1660000	4.51	4.48	2.14E-07
1.806	1.793	1.800 *	90000	1750000	4.57	4.54	2.31E-07
1.828	1.813	1.821 *	80000	1830000	4.64	4.60	2.46E-07
1.850	1.831	1.840 *	65000	1910000	4.70	4.67	2.49E-07
1.867	1.853	1.860 *	75000	1975000	4.77	4.74	3.08E-07
1.887	1.874	1.880 *	68000	2050000	4.84	4.81	2.69E-07
1.907	1.894	1.900 *	60000	2118000	4.92	4.88	3.13E-07
1.927	1.916	1.922 *	63000	2210000	5.06	5.02	3.23E-07
1.946	1.933	1.939 *	60000	2301000	5.14	5.10	3.35E-07
1.964	1.956	1.960 *	50000	2351000	5.22	5.18	4.16E-07
1.984	1.976	1.980 *	40000	2401000	5.30	5.26	3.98E-07
2.007	1.995	2.001 *	36000	2441000	5.39	5.34	4.95E-07
2.026	2.015	2.021 *	33000	2477000	5.47	5.43	5.31E-07
2.047	2.034	2.040 *	25000	2535000	5.55	5.51	6.05E-07
2.066	2.052	2.059 *	35000	2570000	5.65	5.60	6.34E-07
2.084	2.074	2.079 *	30000	2620000	5.74	5.70	5.74E-07
2.105	2.095	2.100 *	27000	2667000	5.84	5.79	6.73E-07
2.125	2.115	2.120 *	20000	267000	5.94	5.89	9.90E-07
2.145	2.136	2.141 *	19000	2686000	6.04	5.99	7.22E-07
2.165	2.156	2.160 *	16000	2702000	6.15	6.09	1.07E-06
2.184	2.176	2.180 *	18000	2720000	6.24	6.20	9.63E-07
2.206	2.196	2.201 *	12000	2732000	6.35	6.30	1.23E-06
2.224	2.215	2.220 *			6.47	6.41	1.12E-06
2.243	2.236	2.239 *			6.61	6.54	1.99E-06
2.263	2.255	2.259 *					
2.286	2.280	2.283 *					

TABLE J30 CONTINUED

TR NUMBER: TR 515-450

CRACK LENGTH--A (INCH)			DELTA CYCLES	TOTAL CYCLES	DELTA K (KSI IN ^{1/2})	AVERAGE DELTA K (KSI IN ^{1/2})	DA/DN (INCH/CYCLE)
FRONT	BACK	AVERAGE					
2.307	2.302	2.304	10000	2742000	6.74	6.67	2.10E-06
2.322	2.316	2.319	9000	2751000	6.83	6.78	1.67E-06
2.343	2.336	2.340	11000	2762000	6.96	6.90	1.65E-06
2.362	2.356	2.359	11000	2773000	7.09	7.03	1.78E-06
2.382	2.377	2.380	9000	2782000	7.23	7.16	2.27E-06
2.402	2.397	2.399	10000	2792000	7.37	7.30	1.97E-06
2.423	2.417	2.420	9500	2801500	7.53	7.45	2.20E-06
2.442	2.436	2.439	8000	2809500	7.67	7.60	2.37E-06
2.461	2.458	2.459	7500	2817400	7.83	7.75	2.56E-06
2.483	2.475	2.479	8500	2825900	7.99	7.91	2.33E-06
2.505	2.494	2.500	8000	2833900	8.16	8.08	2.56E-06
2.522	2.517	2.519	7500	2841400	8.33	8.25	2.63E-06
2.542	2.542	2.542	8000	2849400	8.54	8.44	2.84E-06
2.562	2.557	2.560	5000	2854400	8.71	8.62	3.56E-06
2.581	2.578	2.580	5000	2859400	8.90	8.80	3.94E-06
2.601	2.599	2.600	4500	2863900	9.11	9.01	4.62E-06
2.617	2.621	2.619	3500	2867400	9.31	9.21	5.46E-06
2.639	2.642	2.640	4000	2871800	9.54	9.43	4.75E-06
2.661	2.659	2.660	3700	2875500	9.76	9.65	5.27E-06
2.680	2.680	2.680	4000	2879500	10.00	9.88	5.03E-06
2.702	2.699	2.700	3000	2882500	10.25	10.13	6.80E-06
2.723	2.718	2.720	4000	2886500	10.51	10.38	5.03E-06
2.740	2.738	2.739	3500	2890000	10.76	10.64	5.41E-06
2.762	2.759	2.760	3300	2893300	11.05	10.91	6.32E-06
2.785	2.776	2.781	3300	2896600	11.36	11.20	6.29E-06
2.802	2.799	2.801	3600	2900200	11.66	11.51	5.49E-06
2.825	2.818	2.821	3200	2903400	11.98	11.82	6.37E-06
2.843	2.837	2.840	3500	2906900	12.30	12.14	5.44E-06
2.864	2.855	2.860	2900	2909900	12.63	12.46	6.67E-06
2.883	2.876	2.879	3000	2912800	12.99	12.81	6.65E-06
2.903	2.896	2.899	3000	2915800	13.37	13.18	6.63E-06
2.923	2.917	2.920	3200	2919000	13.78	13.58	6.44E-06
2.944	2.938	2.941	2500	2921500	14.22	14.00	8.34E-06
2.962	2.959	2.961	2300	2923800	14.66	14.44	8.61E-06
2.981	2.978	2.979	2000	2926600	15.09	14.87	6.71E-06
3.002	2.998	3.000	2300	2928900	15.59	15.34	8.87E-06
3.022	3.017	3.020	2700	2931600	16.09	15.84	7.30E-06
3.042	3.038	3.040	3200	2934800	16.65	16.37	6.50E-06
3.062	3.060	3.061	2200	2937000	17.24	16.95	9.34E-06
3.081	3.078	3.080	1800	2938800	17.80	17.52	1.04E-05

TABLE J30 CONTINUED

TR NUMBER: TR 515-450

CRACK LENGTH--A (INCH)			DELTA CYCLES	TOTAL CYCLES	DELTA K (KSI IN ^{1/2})	AVERAGE DELTA K (KSI IN ^{1/2})	DA/DN (INCH/CYCLE)
FRONT	BACK	AVERAGE					
3.102	3.100	3.101	1400	2940200	18.48	18.14	1.52E-05
3.121	3.118	3.120	1600	2941800	19.12	18.80	1.19E-05
3.143	3.138	3.140	1700	2943500	19.85	19.49	1.21E-05
3.164	3.157	3.161	1200	2944700	20.63	20.24	1.70E-05
3.184	3.177	3.180	900	2945600	21.42	21.02	2.17E-05
3.203	3.198	3.201	900	2946500	22.29	21.85	2.26E-05
3.223	3.218	3.221	700	2947200	23.21	22.75	2.88E-05
3.246	3.237	3.241	400	2947600	24.21	23.71	5.10E-05
3.264	3.256	3.260	150	2947750	25.18	24.70	1.24E-04
3.282	3.279	3.281	210	2947960	26.35	25.76	9.95E-05
3.308	3.303	3.305	70	2948030	27.85	27.10	3.54E-04
3.341	3.331	3.336	15	2948045	29.89	28.87	2.03E-03

* DENOTES THAT DATA POINT IS INVALID PER ASIN TEST METHOD E647-88, PARAGRAPH 8.8.3

** DENOTES THAT DATA POINT IS INVALID PER ASIN TEST METHOD E647-88, PARAGRAPH 7.2.1

*** DENOTES THAT DATA POINT IS INVALID PER ASIN TEST METHOD E647-88, PARAGRAPHS 8.8.3 AND 7.2.1

TABLE J31

FIGURE CRACK GROWTH RATE DATA ASSOCIATED WITH FIGURE J11 (Specimen LT2)

TR NUMBER: TR 515-450
 ALLOY: AL2091-T8
 COMMENT: ALCOA MATERIAL
 FTU: 62.2 KSI FTY: 49.5 KSI ULT STRAIN: 0.000 E: 5600 KSI MU: 0.300 ELON: 21.0% RED A: 0.0%
 LOC IN STOCK: UN SPEC THICKNESS: 0.062 IN WIDTH: 4.000 IN MAX TEST LOAD: 0.100 KIPS DATA FILE: AL2091-32

FORM: 0.063 SHEET ORIENT: L-LT R-RATIO: 0.330 ENVIR: LA SPECIMEN TYPE: C(T) GROUP: M&P DATE: 1-MAY-90
 TEMP: 75F FREQ: VAR

CRACK LENGTH--A (INCH)		DELTA K		TOTAL CYCLES		AVERAGE DELTA K		DA/DN	
FRONT	BACK	AVERAGE	DELTA K	DELTA K	DELTA K	DELTA K	DELTA K	DELTA K	DELTA K
1.479	1.482	1.480	85000	85000	85000	4.36	4.39	2.30E-07	2.30E-07
1.496	1.504	1.500	73000	73000	73000	4.42	4.45	2.68E-07	2.68E-07
1.516	1.523	1.519	72000	72000	72000	4.48	4.51	2.95E-07	2.95E-07
1.537	1.544	1.541	65000	65000	65000	4.54	4.57	2.94E-07	2.94E-07
1.556	1.563	1.560	85000	85000	85000	4.60	4.63	2.65E-07	2.65E-07
1.580	1.584	1.582	60000	60000	60000	4.66	4.69	3.05E-07	3.05E-07
1.598	1.603	1.600	50000	50000	50000	4.72	4.75	3.23E-07	3.23E-07
1.617	1.622	1.620	55000	55000	55000	4.78	4.81	3.52E-07	3.52E-07
1.638	1.641	1.640	611000	611000	611000	4.84	4.88	3.58E-07	3.58E-07
1.657	1.661	1.659	45000	45000	45000	4.91	4.94	4.52E-07	4.52E-07
1.677	1.682	1.680	37000	37000	37000	5.05	5.01	5.50E-07	5.50E-07
1.697	1.703	1.700	40000	40000	40000	5.12	5.08	4.60E-07	4.60E-07
1.716	1.724	1.720	34000	34000	34000	5.18	5.15	5.71E-07	5.71E-07
1.737	1.742	1.740	31000	31000	31000	5.26	5.22	6.52E-07	6.52E-07
1.756	1.764	1.760	25000	25000	25000	5.33	5.30	8.20E-07	8.20E-07
1.778	1.783	1.780	26000	26000	26000	5.48	5.37	7.33E-07	7.33E-07
1.795	1.803	1.799	23500	23500	23500	5.48	5.44	8.60E-07	8.60E-07
1.815	1.824	1.820	19000	19000	19000	5.56	5.52	1.04E-06	1.04E-06
1.835	1.844	1.839	24000	24000	24000	5.64	5.60	8.67E-07	8.67E-07
1.856	1.864	1.860	25000	25000	25000	5.72	5.68	7.36E-07	7.36E-07
1.875	1.883	1.879	19330	19330	19330	5.81	5.77	9.95E-07	9.95E-07
1.896	1.904	1.900	15000	15000	15000	5.90	5.85	1.06E-06	1.06E-06
1.915	1.926	1.920	22000	22000	22000	5.98	5.94	1.28E-06	1.28E-06
1.929	1.950	1.940	14100	14100	14100	6.07	6.03	9.23E-07	9.23E-07
1.955	1.965	1.960	16000	16000	16000	6.17	6.12	1.39E-06	1.39E-06
1.976	1.984	1.980	10500	10500	10500	6.26	6.21	1.26E-06	1.26E-06
1.995	2.004	2.000	17000	17000	17000	6.36	6.31	1.17E-06	1.17E-06
2.017	2.023	2.020	15000	15000	15000	6.46	6.41	1.35E-06	1.35E-06
2.036	2.044	2.040	12500	12500	12500	6.56	6.51	1.33E-06	1.33E-06
2.055	2.065	2.060	10000	10000	10000	6.67	6.62	1.61E-06	1.61E-06
2.075	2.085	2.080	10500	10500	10500	6.78	6.72	1.94E-06	1.94E-06
2.095	2.105	2.100	12000	12000	12000	6.89	6.83	1.65E-06	1.65E-06
2.116	2.124	2.120	11000	11000	11000	7.00	6.95	1.82E-06	1.82E-06
2.137	2.144	2.140	10000	10000	10000	7.12	7.06	1.97E-06	1.97E-06
2.156	2.164	2.160	8500	8500	8500	7.25	7.18	2.05E-06	2.05E-06
2.176	2.184	2.180	9000	9000	9000	7.37	7.31	2.28E-06	2.28E-06
2.196	2.204	2.200	9000	9000	9000	7.49	7.43	2.18E-06	2.18E-06
2.215	2.224	2.219	9000	9000	9000	7.63	7.56	2.11E-06	2.11E-06
2.235	2.245	2.240	9000	9000	9000	7.76	7.70	2.19E-06	2.19E-06
2.257	2.263	2.260	9000	9000	9000	7.76	7.70	2.19E-06	2.19E-06

TABLE J31 CONTINUED

TR NUMBER: TR 515-458

CRACK LENGTH--A (INCH)			DELTA CYCLES	TOTAL CYCLES	DELTA K (KSI IN ^{1/2})	AVERAGE DELTA K (KSI IN ^{1/2})	DA/DN (INCH/CYCLE)
FRONT	BACK	AVERAGE					
2.276	2.284	2.280	8500	1210430	7.91	7.83	2.38E-06
2.296	2.303	2.300	9000	1219430	8.05	7.98	2.22E-06
2.313	2.324	2.318	8000	1217430	8.19	8.12	2.32E-06
2.337	2.345	2.341	7500	1234930	8.37	8.28	3.06E-06
2.357	2.364	2.361	6000	1240930	8.52	8.44	3.22E-06
2.376	2.384	2.380	6700	1247630	8.68	8.60	2.86E-06
2.399	2.403	2.401	6700	1254330	8.86	8.77	3.16E-06
2.416	2.424	2.420	5500	1259830	9.03	8.94	3.41E-06
2.437	2.442	2.439	5900	1265730	9.21	9.12	3.35E-06
2.458	2.462	2.460	6600	1272330	9.40	9.30	3.13E-06
2.477	2.485	2.481	5500	1277830	9.61	9.50	3.79E-06
2.496	2.505	2.500	5200	1283030	9.80	9.70	3.76E-06
2.515	2.524	2.519	4900	1287930	10.00	9.90	3.87E-06
2.538	2.544	2.541	4500	1292430	10.24	10.12	4.77E-06
2.555	2.563	2.559	4000	1296430	10.44	10.34	4.68E-06
2.577	2.581	2.579	4300	1300730	10.67	10.56	4.59E-06
2.591	2.607	2.599	5300	1306030	10.92	10.80	3.83E-06
2.615	2.625	2.620	5400	1311430	11.19	11.05	3.91E-06
2.636	2.644	2.640	6500	1317930	11.44	11.32	3.00E-06
2.655	2.665	2.660	5000	1322930	11.71	11.58	3.94E-06
2.680	2.682	2.681	5000	1327930	12.02	11.87	4.34E-06
2.695	2.704	2.700	2500	1330430	12.29	12.16	7.40E-06
2.715	2.725	2.720	5000	1335430	12.61	12.45	4.04E-06
2.735	2.744	2.739	7000	1342430	12.92	12.76	2.77E-06
2.755	2.766	2.760	5500	1347930	13.26	13.09	3.76E-06
2.778	2.783	2.780	4300	1352230	13.62	13.44	4.72E-06
2.798	2.802	2.800	3600	1355830	13.97	13.79	5.40E-06
2.819	2.823	2.821	5000	1360830	14.37	14.17	4.21E-06
2.837	2.841	2.839	4700	1365530	14.74	14.56	3.94E-06
2.857	2.864	2.861	5900	1371430	15.18	14.96	3.61E-06
2.877	2.882	2.879	5300	1376730	15.59	15.39	3.53E-06
2.897	2.904	2.900	5000	1381730	16.07	15.83	4.18E-06
2.918	2.921	2.920	4300	1386030	16.53	16.30	4.52E-06
2.936	2.942	2.939	3900	1389930	17.03	16.78	5.04E-06
2.955	2.967	2.961	3300	1393230	17.60	17.32	6.61E-06
2.978	2.981	2.980	3200	1396430	18.12	17.86	5.77E-06
2.998	3.003	3.000	3600	1400030	18.72	18.42	5.72E-06
3.016	3.024	3.020	3250	1403280	19.33	19.02	6.14E-06
3.038	3.041	3.040	3300	1406580	19.96	19.64	5.86E-06
3.056	3.064	3.060	3100	1409680	20.65	20.30	6.55E-06

TABLE J31. CONTINUED

TR NUMBER: TR 515-450

CRACK LENGTH--A (INCH)		DELTA CYCLES		TOTAL CYCLES	DELTA K (KSI IN ^{-1/2})	AVERAGE DELTA K (KSI IN ^{-1/2})	DA/DN (INCH/CYCLE)
FRONT	BACK	AVERAGE					
3.076	3.084	3.080	3000	1412680	21.38	21.02	6.73E-06
3.098	3.105	3.101	2500	1415180	22.19	21.79	8.48E-06
3.116	3.126	3.121	1500	1416680	23.00	22.59	1.32E-05
3.137	3.145	3.141	1100	1417780	23.86	23.43	1.82E-05
3.151	3.167	3.159 *	800	1418580	24.68	24.27	2.24E-05

* - DENOTES THAT DATA POINT IS INVALID PER ASTM TEST METHOD E647-88, PARAGRAPH 8.8.3

** - DENOTES THAT DATA POINT IS INVALID PER ASTM TEST METHOD E647-88, PARAGRAPH 7.2.1

*** - DENOTES THAT DATA POINT IS INVALID PER ASTM TEST METHOD E647-88, PARAGRAPHS 8.8.3 AND 7.2.1

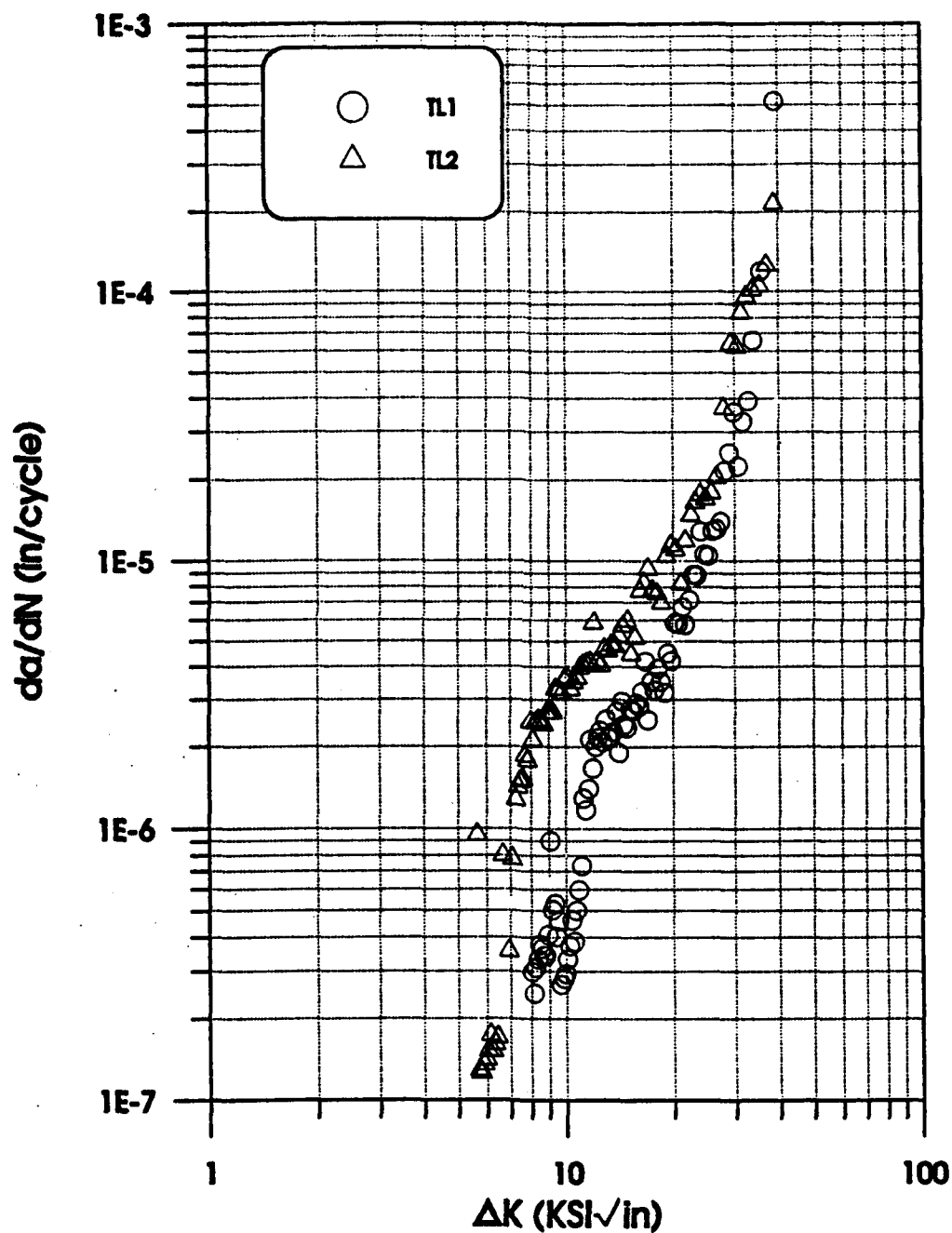


Figure J12 Fatigue Crack Growth Rate Data for
 2091-T8 0.063 Inch Sheet (T-L Orientation,
 Lab Air, 75°F, and TL1 R=0.02 and TL2 R=0.10).
 McDonnell Aircraft Company

TABLE J32

FATIGUE CRACK GROWTH RATE DATA ASSOCIATED WITH FIGURE J12 (Specimen TL1)

TR NUMBER: TR 515-450
 ALLOY: AL2091-T8
 COMMENT: ALCOA MATERIAL
 FTU: 65.2 KSI FTY: 42.3 KSI ULT STRAIN: 0.000 E: 5700 KSI MU: 0.300 ELON: 10.3% RED A: 0.0%
 LOC IN STOCK: UN SPEC THICKNESS: 0.062 IN WIDTH: 4.000 IN MAX TEST LOAD: 0.200 KIPS DATA FILE: AL-27
 FORM: 0.063 SHEET ORIENT: LT-L R-RATIO: 0.020 ENVIR: LA TEMP: 75F FREQ: VAR
 SPECIMEN TYPE: C(T) GROUP: MAP DATE: 1-MAY-90

CRACK LENGTH--A (INCH)				DELTA CYCLES	TOTAL CYCLES	DELTA K (KSI IN ^{1/2})	AVERAGE DELTA K (KSI IN ^{1/2})	DA/DN (INCH/CYCLE)
FRONT	BACK	AVERAGE						
1.498	1.462	1.488	*	65000	0	7.98	0.03	2.90E-07
1.518	1.481	1.499	*	85000	65000	8.08	0.13	2.40E-07
1.540	1.501	1.521	*	85000	150000	8.19	0.24	3.10E-07
1.559	1.521	1.540	*	62500	212500	8.29	0.35	3.32E-07
1.578	1.542	1.560	*	60000	272500	8.40	0.46	3.77E-07
1.598	1.560	1.579	*	52000	324500	8.51	0.57	3.64E-07
1.617	1.583	1.600	*	58250	380750	8.63	0.69	3.42E-07
1.637	1.604	1.620	*	60000	440750	8.75	0.80	3.42E-07
1.656	1.622	1.639	*	55000	495750	8.86	0.92	4.09E-07
1.680	1.639	1.660	*	50000	545750	8.98	0.84	4.73E-07
1.701	1.661	1.681	*	45000	590750	9.11	0.94	5.05E-07
1.721	1.679	1.700	*	38000	628750	9.23	0.17	5.30E-07
1.740	1.700	1.720	*	37000	665750	9.35	0.29	4.02E-07
1.764	1.718	1.741	*	53000	718750	9.49	0.42	4.58E-07
1.780	1.739	1.759	*	40000	758750	9.61	0.55	2.69E-07
1.801	1.761	1.781	*	80000	838750	9.75	0.68	2.83E-07
1.820	1.784	1.802	*	75000	913750	9.90	0.83	2.94E-07
1.838	1.802	1.820	*	60000	973750	10.03	0.96	3.33E-07
1.860	1.819	1.839	*	59000	1032750	10.17	10.10	3.73E-07
1.884	1.836	1.860	*	55000	1087750	10.32	10.24	4.61E-07
1.896	1.862	1.879	*	42000	1129750	10.46	10.39	3.65E-07
1.919	1.882	1.900	*	55000	1184750	10.63	10.54	5.00E-07
1.939	1.901	1.920	*	40000	1224750	10.78	10.70	5.97E-07
1.958	1.921	1.940	*	32000	1256750	10.94	10.86	7.33E-07
1.980	1.943	1.961	*	30000	1288750	11.12	11.03	1.29E-06
2.001	1.961	1.981	*	15000	1301750	11.28	11.20	1.17E-06
2.019	1.982	2.001	*	17000	1318750	11.46	11.37	1.40E-06
2.042	2.001	2.022	*	15000	1333750	11.65	11.55	2.13E-06
2.060	2.022	2.041	*	9000	1342750	11.82	11.73	1.67E-06
2.078	2.042	2.060	*	11500	1354250	12.00	11.91	2.00E-06
2.099	2.061	2.080	*	10000	1364250	12.20	12.10	2.17E-06
2.118	2.081	2.100	*	9000	1373250	12.39	12.29	2.30E-06
2.137	2.102	2.119	*	8500	1381750	12.59	12.49	2.09E-06
2.159	2.126	2.142	*	11000	1392750	12.83	12.71	2.54E-06
2.180	2.145	2.162	*	6000	1400750	13.05	12.94	2.16E-06
2.199	2.163	2.181	*	8500	1409250	13.25	13.15	2.18E-06
2.219	2.181	2.200	*	8750	1418000	13.47	13.36	2.28E-06
2.240	2.203	2.222	*	9500	1427500	13.73	13.60	2.71E-06
2.260	2.221	2.240	*	7000	1434500	13.96	13.84	1.90E-06
2.274	2.245	2.260	*	10000	1444500	14.19	14.07	

TABLE J32 CONTINUED

TR NUMBER: TR 515-450

CRACK LENGTH--A (INCH)		AVERAGE	DELTA CYCLES	TOTAL CYCLES	DELTA K (KSI IN ^{1/2})	AVERAGE DELTA K (KSI IN ^{1/2})	DA/DN (INCH/CYCLE)
FRONT	BACK						
2.299	2.262	2.280 *	7000	1451500	14.46	14.33	2.90E-06
2.317	2.285	2.301 *	8500	1460000	14.73	14.60	2.42E-06
2.334	2.305	2.320 *	8000	1468000	14.99	14.86	2.36E-06
2.357	2.324	2.340 *	7500	1475500	15.29	15.14	2.76E-06
2.376	2.343	2.360 *	7000	1482500	15.57	15.43	2.73E-06
2.395	2.365	2.380 *	7000	1489500	15.87	15.72	2.91E-06
2.424	2.381	2.403 *	8000	1497500	16.23	16.05	2.84E-06
2.441	2.403	2.422 *	6000	1503500	16.54	16.38	3.22E-06
2.457	2.424	2.441 *	4500	1508000	16.86	16.70	4.19E-06
2.476	2.444	2.460 *	7500	1515500	17.19	17.02	3.52E-06
2.499	2.462	2.481 *	6000	1521500	17.56	17.37	3.52E-06
2.520	2.484	2.502 *	6500	1528000	17.96	17.76	3.26E-06
2.535	2.507	2.521 *	4750	1532750	18.32	18.14	3.94E-06
2.553	2.525	2.539 *	5250	1538000	18.68	18.50	3.52E-06
2.578	2.545	2.562 *	7000	1545000	19.15	18.91	3.19E-06
2.594	2.566	2.580 *	4000	1549000	19.53	19.34	4.50E-06
2.617	2.588	2.603 *	5500	1554500	20.05	19.79	4.22E-06
2.641	2.606	2.623 *	3500	1558000	20.53	20.29	5.87E-06
2.656	2.625	2.641 *	3000	1561000	20.94	20.74	5.08E-06
2.676	2.646	2.661 *	3000	1564000	21.45	21.20	6.70E-06
2.700	2.659	2.679 *	3200	1567200	21.92	21.69	5.75E-06
2.718	2.684	2.701 *	3000	1570200	22.50	22.21	7.13E-06
2.739	2.703	2.721 *	2300	1572500	23.08	22.79	8.89E-06
2.759	2.724	2.741 *	2300	1574800	23.68	23.38	8.85E-06
2.774	2.748	2.761 *	1500	1576300	24.27	23.97	1.29E-05
2.797	2.763	2.780 *	1800	1578100	24.88	24.57	1.06E-05
2.819	2.781	2.800 *	1900	1580000	25.55	25.21	1.05E-05
2.835	2.805	2.820 *	1550	1581550	26.25	25.90	1.30E-05
2.853	2.827	2.846 *	1500	1583550	26.97	26.61	1.32E-05
2.872	2.850	2.861 *	1500	1584550	27.77	27.37	1.40E-05
2.893	2.867	2.880 *	900	1585450	28.54	28.15	2.16E-05
2.915	2.886	2.900 *	800	1586250	29.38	28.96	2.51E-05
2.931	2.909	2.920 *	550	1586800	30.23	29.81	3.55E-05
2.950	2.930	2.940 *	900	1587700	31.16	30.70	2.24E-05
2.973	2.947	2.960 *	600	1588300	32.11	31.64	3.28E-05
2.995	2.971	2.983 *	600	1588900	33.31	32.71	3.93E-05
3.021	2.993	3.007 *	36	1589250	34.59	33.95	6.58E-05
3.055	3.028	3.041 *	290	1589550	36.61	35.60	1.19E-04
3.126	3.100	3.113***	140	1589690	41.45	39.03	5.13E-04

* - DENOTES THAT DATA POINT IS INVALID PER ASTM TEST METHOD E647-88, PARAGRAPH 8.8.3

** - DENOTES THAT DATA POINT IS INVALID PER ASTM TEST METHOD E647-88, PARAGRAPH 7.2.1

*** - DENOTES THAT DATA POINT IS INVALID PER ASTM TEST METHOD E647-88, PARAGRAPHS 8.8.3 AND 7.2.1

TABLE J33

FATIGUE CRACK GROWTH RATE DATA ASSOCIATED WITH FIGURE J12 (SPECIMEN TL2)

CRACK LENGTH--A (INCH)		TOTAL CYCLES		DELTA K (KSI IN ^{1/2})		AVERAGE DELTA K (KSI IN ^{1/2})		DA/DN (INCH/CYCLE)	
FRONT	BACK	DELTA CYCLES	AVERAGE	DELTA K (KSI IN ^{1/2})	AVERAGE DELTA K (KSI IN ^{1/2})	DELTA K (KSI IN ^{1/2})	AVERAGE DELTA K (KSI IN ^{1/2})	DA/DN (INCH/CYCLE)	
1.671	1.668	168150	1.670	5.53	5.57	5.53	5.57	1.29E-07	---
1.695	1.688	168150	1.691	5.62	5.65	5.62	5.65	9.50E-08	---
1.714	1.707	200000	1.710	5.69	5.73	5.69	5.73	1.26E-07	---
1.733	1.727	155000	1.730	5.76	5.80	5.76	5.80	1.26E-07	---
1.751	1.748	155000	1.749	5.84	5.89	5.84	5.89	1.35E-07	---
1.773	1.767	155000	1.770	5.93	5.97	5.93	5.97	1.41E-07	---
1.792	1.788	140000	1.790	6.01	6.05	6.01	6.05	1.52E-07	---
1.815	1.806	135000	1.810	6.10	6.14	6.10	6.14	1.74E-07	---
1.835	1.826	115000	1.830	6.18	6.23	6.18	6.23	1.51E-07	---
1.853	1.847	130000	1.850	6.27	6.32	6.27	6.32	1.61E-07	---
1.874	1.868	130000	1.871	6.37	6.42	6.37	6.42	1.70E-07	---
1.893	1.890	120000	1.891	6.46	6.51	6.46	6.51	1.70E-07	---
1.975	1.971	102000	1.973	6.87	6.92	6.87	6.92	3.56E-07	---
1.994	1.989	53000	1.992	6.97	7.07	6.97	7.07	7.75E-07	---
2.031	2.030	50000	2.030	7.18	7.23	7.18	7.23	1.28E-06	---
2.051	2.048	15000	2.050	7.29	7.34	7.29	7.34	1.42E-06	---
2.073	2.066	14000	2.069	7.40	7.47	7.40	7.47	1.49E-06	---
2.090	2.090	14000	2.090	7.53	7.59	7.53	7.59	1.51E-06	---
2.111	2.109	13000	2.110	7.65	7.71	7.65	7.71	1.85E-06	---
2.132	2.129	11000	2.130	7.78	7.84	7.78	7.84	1.77E-06	---
2.152	2.148	11000	2.150	7.90	7.97	7.90	7.97	2.47E-06	---
2.173	2.166	8000	2.169	8.04	8.11	8.04	8.11	2.12E-06	---
2.191	2.188	9500	2.190	8.18	8.24	8.18	8.24	2.46E-06	---
2.212	2.207	8000	2.209	8.31	8.39	8.31	8.39	2.52E-06	---
2.232	2.227	8000	2.230	8.46	8.54	8.46	8.54	2.50E-06	---
2.251	2.248	8000	2.249	8.61	8.69	8.61	8.69	2.42E-06	---
2.272	2.268	8500	2.270	8.77	8.85	8.77	8.85	2.68E-06	---
2.291	2.289	7500	2.290	8.93	9.02	8.93	9.02	2.68E-06	---
2.313	2.307	7500	2.310	9.10	9.18	9.10	9.18	3.30E-06	---
2.333	2.326	7250	2.330	9.27	9.36	9.27	9.36	3.27E-06	---
2.355	2.347	6400	2.351	9.45	9.54	9.45	9.54	3.17E-06	---
2.374	2.368	6200	2.371	9.64	9.72	9.64	9.72	3.57E-06	---
2.392	2.387	5800	2.389	9.81	9.91	9.81	9.91	3.64E-06	---
2.412	2.406	5600	2.409	10.00	10.10	10.00	10.10	3.28E-06	---
2.431	2.427	5400	2.429	10.20	10.31	10.20	10.31	3.49E-06	---
2.453	2.448	5500	2.450	10.42	10.52	10.42	10.52	3.62E-06	---
2.473	2.466	5500	2.470	10.63	10.74	10.63	10.74	3.96E-06	---
2.493	2.486	5500	2.489	10.85	10.96	10.85	10.96	4.06E-06	---
2.512	2.507	5000	2.509	11.08	11.20	11.08	11.20		---
2.532	2.527	5000	2.530	11.32		11.32			---

TABLE J33 CONTINUED

TR NUMBER: TR 515-450

CRACK LENGTH--A (INCH)				DELTA CYCLES	TOTAL CYCLES	DELTA K (KSI IN ^{1/2})	AVERAGE DELTA K (KSI IN ^{1/2})	DA/DN (INCH/CYCLE)
FRONT	BACK	AVERAGE						
2.554	2.549	2.551	5250	2020550	11.59	11.45	4.13E-06	
2.576	2.566	2.571	4250	2024800	11.84	11.72	4.61E-06	
2.592	2.588	2.590	3250	2028050	12.10	11.97	5.86E-06	
2.613	2.613	2.613	5500	2033550	12.42	12.26	4.20E-06	
2.634	2.627	2.630	4250	2037800	12.67	12.54	4.04E-06	
2.654	2.648	2.651	4000	2042200	12.97	12.82	4.67E-06	
2.676	2.665	2.671	4350	2046550	13.29	13.13	4.59E-06	
2.696	2.686	2.691	4200	2050750	13.62	13.45	4.83E-06	
2.715	2.706	2.710	4000	2054750	13.94	13.78	4.78E-06	
2.733	2.728	2.731	3900	2058650	14.30	14.12	5.23E-06	
2.753	2.748	2.751	3500	2062150	14.66	14.48	5.71E-06	
2.773	2.767	2.770	3250	2065400	15.04	14.85	5.97E-06	
2.793	2.787	2.790	4500	2069900	15.43	15.23	4.44E-06	
2.814	2.806	2.810	4000	2073900	15.86	15.65	5.13E-06	
2.833	2.827	2.830	2500	2076400	16.28	16.07	7.72E-06	
2.853	2.848	2.850	2500	2078900	16.75	16.52	8.28E-06	
2.873	2.867	2.870	2100	2081000	17.22	16.99	9.38E-06	
2.892	2.887	2.890	2500	2083500	17.71	17.47	7.76E-06	
2.913	2.906	2.910	2650	2086150	18.23	17.97	7.55E-06	
2.935	2.924	2.930	2900	2089050	18.78	18.51	6.95E-06	
2.951	2.954	2.953	2200	2091250	19.45	19.12	1.04E-05	
2.976	2.965	2.971	1600	2092850	20.00	19.73	1.14E-05	
2.999	2.991	2.995	2200	2095850	20.78	20.39	1.10E-05	
3.015	3.008	3.011	1950	2097000	21.32	21.05	8.18E-06	
3.036	3.031	3.034	1900	2098900	22.12	21.72	1.19E-05	
3.053	3.049	3.051	1200	2100100	22.79	22.46	1.48E-05	
3.073	3.066	3.070	1100	2101200	23.50	23.14	1.65E-05	
3.093	3.087	3.090	1150	2102350	24.34	23.92	1.77E-05	
3.111	3.107	3.109	1150	2103500	25.20	24.77	1.70E-05	
3.133	3.128	3.131	1200	2104700	26.20	25.70	1.79E-05	
3.153	3.146	3.149	900	2105600	27.11	26.66	2.05E-05	
3.180	3.174	3.177	760	2106360	28.59	27.85	3.66E-05	
3.209	3.196	3.203	400	2106760	30.06	29.32	6.39E-05	
3.220	3.207	3.214	175	2106935	30.72	30.39	6.23E-05	
3.236	3.225	3.230	200	2107135	31.78	31.25	8.32E-05	
3.253	3.246	3.249	200	2107335	33.08	32.43	9.55E-05	
3.274	3.265	3.269	200	2107535	34.54	33.81	1.01E-04	
3.292	3.289	3.290	200	2107735	36.17	35.35	1.05E-04	
3.311	3.307	3.309	150	2107885	37.73	36.95	1.25E-04	
3.336	3.325	3.331	100	2107985	39.66	38.69	2.14E-04	
3.359	3.343	3.351	70	2108055	41.67	40.66	2.56E-04	
3.380	3.362	3.371	50	2108105	43.78	42.73	4.02E-04	

APPENDIX K

**2091-T3 and 2091-T8
0.144 Inch Sheet**

TABLE K1

TENSILE RESULTS FOR ALCOA

2091-T3 SHEET (0.144" X 48" X 48")

COMPANY	TEST TEMP (DEGREES F)	ORIENT- ATION	ULTIMATE STRENGTH (KSI)	YIELD STRENGTH (KSI)	ELONG (%)	RA (%)	E (MSI)
MCDONNELL	RT	LONG	59.4	49.0	20.0		11.4
DOUGLAS			60.1	49.2	20.0		11.6
ASTRO., CA			59.9	49.5	20.0		11.5
			59.9	49.6	20.0		11.5
			58.9	49.5	22.0		11.5
MARTIN							
MARIETTA, LA	RT	LONG	60.6	50.0	17.0	12.7	11.4
			59.9	49.6	17.0	15.5	11.1
			59.9	49.6	17.0	19.7	11.4
AIR FORCE	RT	LONG	61.4	51.1	14.3	14.7	
			61.4	50.9	17.9	20.5	
			61.4	51.3	17.2	19.7	
		AVERAGE	60.3	49.9	18.4	17.1	11.4
		STANDARD DEVIATION	0.8	0.8	2.2	3.2	0.1

TABLE K2

TENSILE RESULTS FOR ALCOA

2091-T3 SHEET (0.144" X 48" X 48")

COMPANY	TEST TEMP (DEGREES F)	ORIENT- ATION	ULTIMATE STRENGTH (KSI)	YIELD STRENGTH (KSI)	ELONG (%)	RA (%)	E (MSI)
AIR FORCE	RT	30	62.4	45.0	20.0	25.6	
			62.1	44.0	19.1	25.4	
			62.2	43.2	18.9	25.5	
		AVERAGE	62.2	44.1	19.3	25.5	
		STANDARD DEVIATION	0.2	0.9	0.6	0.1	

TABLE K3

TENSILE RESULTS FOR ALCOA

2091-T3 SHEET (0.144" X 48" X 48")

COMPANY	TEST TEMP (DEGREES F)	ORIENT- ATION	ULTIMATE STRENGTH (KSI)	YIELD STRENGTH (KSI)	ELONG (%)	RA (%)	E (MSI)
AIR FORCE	RT	45	61.4	42.0	23.3	28.3	
			61.6	42.7	24.4	28.2	
			61.5	42.7	23.9	29.3	
	AVERAGE		61.5	42.5	23.9	28.6	
	STANDARD DEVIATION		0.1	0.4	0.6	0.6	

TABLE K4

TENSILE RESULTS FOR ALCOA

2091-T3 SHEET (0.144" X 48" X 48")

COMPANY	TEST TEMP (DEGREES F)	ORIENT- ATION	ULTIMATE STRENGTH (KSI)	YIELD STRENGTH (KSI)	ELONG (%)	RA (%)	E (MSI)		
AIR FORCE	RT	60	61.2	40.9	24.0	29.0			
			61.0	43.3	21.5	27.8			
			60.3	41.5	22.8	31.1			
			AVERAGE			60.8	41.9	22.8	29.3
			STANDARD DEVIATION			0.5	1.2	1.3	1.7

TABLE K5

TENSILE RESULTS FOR ALCOA

2091-T3 SHEET (0.144" X 48" X 48")

COMPANY	TEST TEMP (DEGREES F)	ORIENT- ATION	ULTIMATE STRENGTH (KSI)	YIELD STRENGTH (KSI)	ELONG (%)	RA (%)	E (MSI)
MCDONNELL	RT	L TRANS	64.3				12.0
DOUGLAS			65.3	46.6	14.0		11.6
ASTRO., CA			65.2	46.6	14.0		11.6
			64.3	46.4	12.5		11.5
			64.6	46.7	12.5		11.6
MARTIN	RT	L TRANS	64.7	46.2	12.0	12.7	11.1
MARIETTA, LA			65.1	45.8	13.0	11.3	11.4
			64.7	45.6	13.0	11.3	11.3
AIR FORCE	RT	L TRANS	66.0	47.3	16.4	16.2	
			66.4	47.4	17.5	17.3	
			66.0	47.5	15.7	18.8	
AVERAGE			65.1	46.6	14.1	14.6	11.5
STANDARD DEVIATION			0.7	0.6	1.9	3.3	0.3

TABLE K6

TENSILE RESULTS FOR ALCOA

2091-T3 SHEET (0.144" X 48" X 48")

COMPANY	TEST TEMP (DEGREES F)	ORIENT- ATION	ULTIMATE STRENGTH (KSI)	YIELD STRENGTH (KSI)	ELONG (%)	RA (%)	E (MSI)
MCDONNELL	-320 F	LONG	75.3	57.6	16.0		12.4
DOUGLAS			76.2	58.1	16.5		12.5
ASTRO., CA			75.1	57.4	17.0		12.5
			75.0	58.0	17.0		12.5
AVERAGE			75.4	57.8	16.6		12.5
STANDARD DEVIATION			0.5	0.3	0.5		0.1

TABLE K7

TENSILE RESULTS FOR ALCOA

2091-T3 SHEET (0.144" X 48" X 48")

COMPANY	TEST TEMP (DEGREES F)	ORIENT- ATION	ULTIMATE STRENGTH (KSI)	YIELD STRENGTH (KSI)	ELONG (%)	RA (%)	E (MSI)
MCDONNELL	-320 F	L TRANS	81.6	53.9	16.5		12.7
DOUGLAS			82.2	54.2	14.5		12.7
ASTRO., CA			81.5	55.1	14.5		12.7
			80.6	55.1	13.0		12.5
		AVERAGE	81.5	54.6	14.6		12.7
		STANDARD DEVIATION	0.7	0.6	1.4		0.1

TABLE K8

COMPRESSION RESULTS FOR ALCOA

2091-T3 SHEET (0.144" X 48" X 48")

COMPANY	TEST TEMPERATURE (DEGREES F)	ORIENTATION	COMPRESSIVE YIELD STRENGTH (KSI)	COMPRESSIVE MODULUS (KSI)
MCDONNELL	RT	LONG	41.1	11.5
DOUGLAS				11.5
ASTRO., CA			40.7	11.4
AVERAGE			40.9	11.5
STANDARD DEVIATION			0.3	0.1

TABLE K9

COMPRESSION RESULTS FOR ALCOA

2091-T3 SHEET (0.144" X 48" X 48")

COMPANY	TEST TEMPERATURE (DEGREES F)	ORIENTATION	COMPRESSIVE YIELD STRENGTH (KSI)	COMPRESSIVE MODULUS (KSI)
MCDONNELL	RT	L TRANS	49.0	11.3
DOUGLAS			48.6	11.5
ASTRO., CA			49.8	11.5
AVERAGE			49.1	11.4
STANDARD DEVIATION			0.6	0.1

TABLE K10

COMPRESSION RESULTS FOR ALCOA

2091-T3 SHEET (0.144" X 48" X 48")

COMPANY	TEST TEMPERATURE (DEGREES F)	ORIENTATION	COMPRESSIVE YIELD STRENGTH (KSI)	COMPRESSIVE MODULUS (KSI)
MCDONNELL	-320 F	LONG	46.8	12.7
DOUGLAS				12.5
ASTRO., CA			46.4	12.4
		AVERAGE	46.6	12.5
		STANDARD DEVIATION	0.3	0.2

TABLE K11

COMPRESSION RESULTS FOR ALCOA

2091-T3 SHEET (0.144" X 48" X 48")

COMPANY	TEST TEMPERATURE (DEGREES F)	ORIENTATION	COMPRESSIVE YIELD STRENGTH (KSI)	COMPRESSIVE MODULUS (KSI)
MCDONNELL	-320 F	L TRANS	56.8	12.8
DOUGLAS			55.1	12.8
ASTRO., CA			58.8	12.5
		AVERAGE	56.9	12.7
		STANDARD DEVIATION	1.9	0.2

TABLE K12
BEARING RESULTS FOR ALCOA
2091-T3 SHEET (0.144" X 48" X 48")

COMPANY	ORIENTATION	e/D	BEARING ULT. STR. (KSI)	BEARING YIELD STR. (KSI)
MCDONNELL	LONG	1.5	95.6	
DOUGLAS			95.9	75.3
ASTRO., CA			95.3	75.8
			95.2	74.3
			95.1	72.9
		AVERAGE	95.4	74.6
		STANDARD DEVIATION	0.3	1.3

TABLE K13
BEARING RESULTS FOR ALCOA
2091-T3 SHEET (0.144" X 48" X 48")

COMPANY	ORIENTATION	e/D	BEARING ULT. STR. (KSI)	BEARING YIELD STR. (KSI)
MCDONNELL	L TRANS	1.5	98.1	75.3
DOUGLAS			98.2	74.2
ASTRO., CA			98.5	78.6
			96.5	74.6
			98.1	
		AVERAGE	97.9	75.7
		STANDARD DEVIATION	0.8	2.0

TABLE K14

BEARING RESULTS FOR ALCOA

2091-T3 SHEET (0.144" X 48" X 48")

COMPANY	ORIENTATION	e/D	BEARING		BEARING			
			ULT.	STR.	YIELD	STR.		
			(KSI)		(KSI)			
MCDONNELL	LONG	2.0	119.0		86.2			
DOUGLAS			119.0					
ASTRO., CA			120.0		86.6			
			120.0					
			120.0		85.3			
AVERAGE			119.6		86.0			
STANDARD DEVIATION			0.5		0.7			

TABLE K15

BEARING RESULTS FOR ALCOA

2091-T3 SHEET (0.144" X 48" X 48")

COMPANY	ORIENTATION	e/D	BEARING		BEARING	
			ULT.	STR.	YIELD	STR.
			(KSI)		(KSI)	
MCDONNELL	L TRANS	2.0	122.0		89.2	
DOUGLAS			122.0		90.7	
ASTRO., CA			122.0			
			123.0		88.7	
			121.0		87.9	
AVERAGE			122.0		89.1	
STANDARD DEVIATION			0.7		1.2	

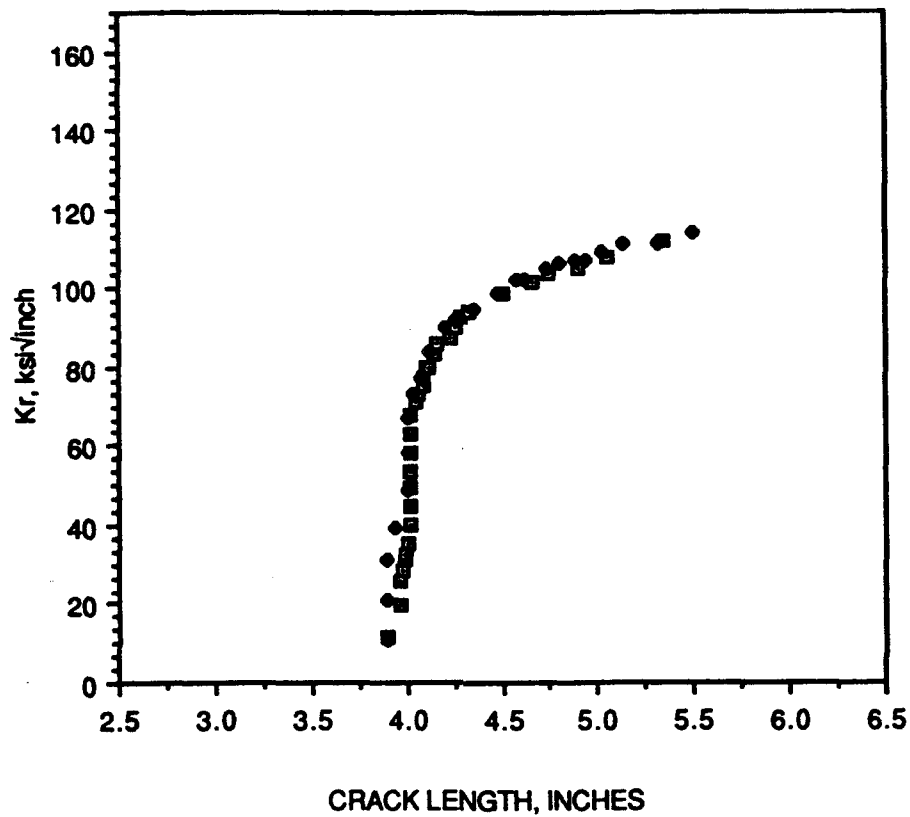


Figure K1. R-Curve Results for 2091-T3
0.144 Inch Sheet (L-T Orientation).
Martin Marietta

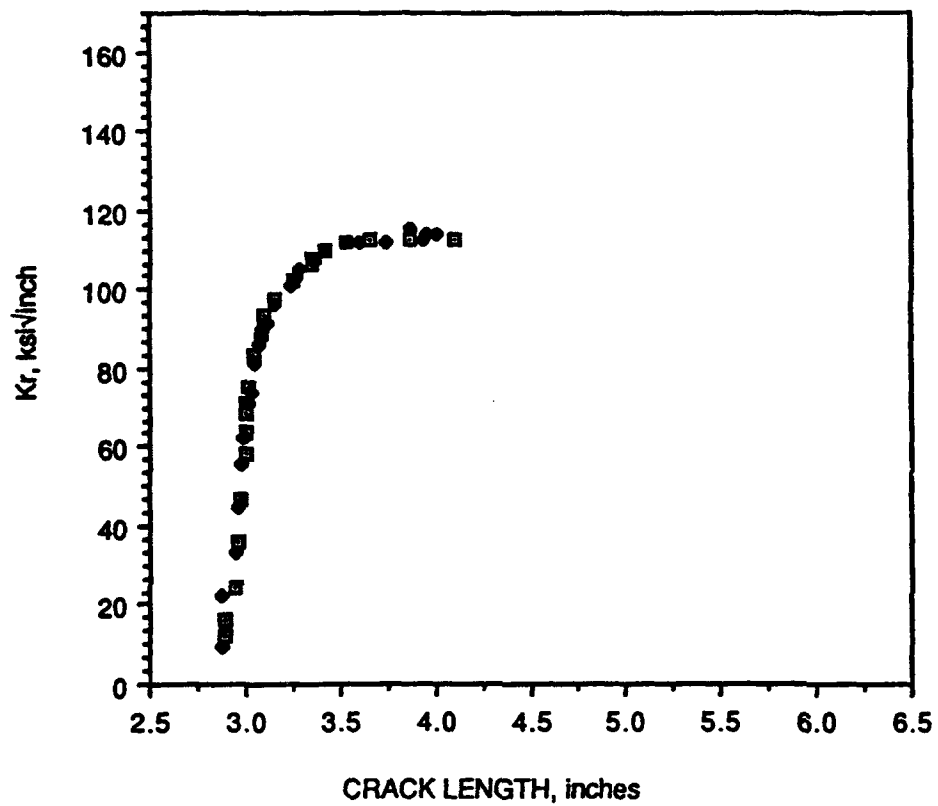


Figure K2. R-Curve Results for 2091-T3 0.144
Inch Sheet (T-L Orientation).
Martin Marietta.

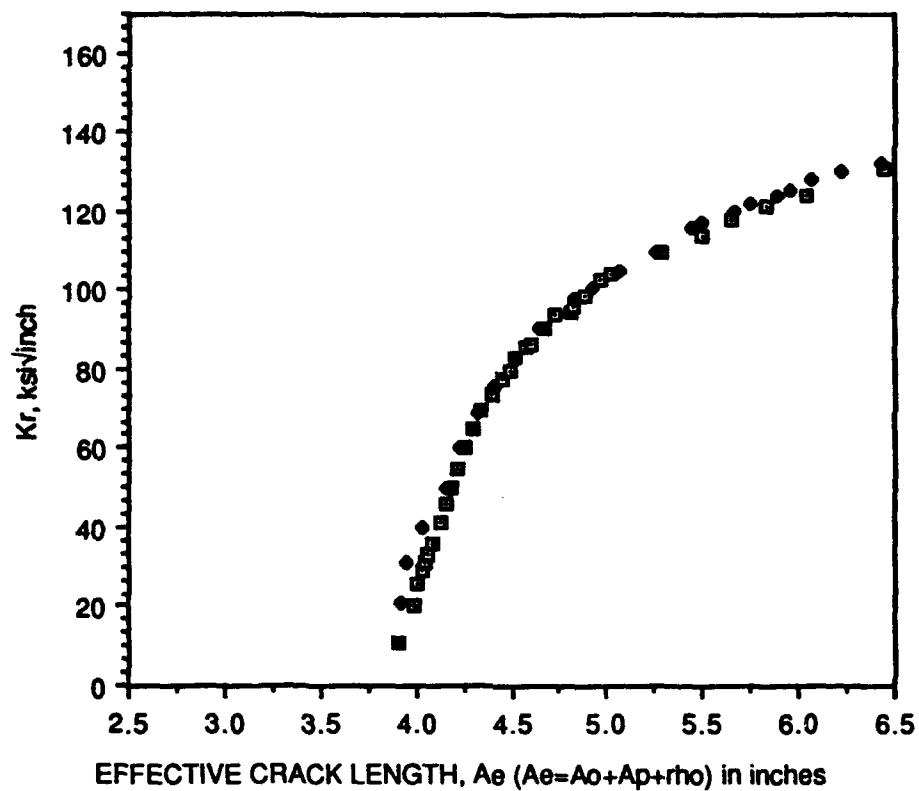


Figure K3. R-Curve Results for 2091-T3
0.144 Inch Sheet with Effective Crack Length
Adjusted for Plastic Zone (L-T Orientation)
Martin Marietta.

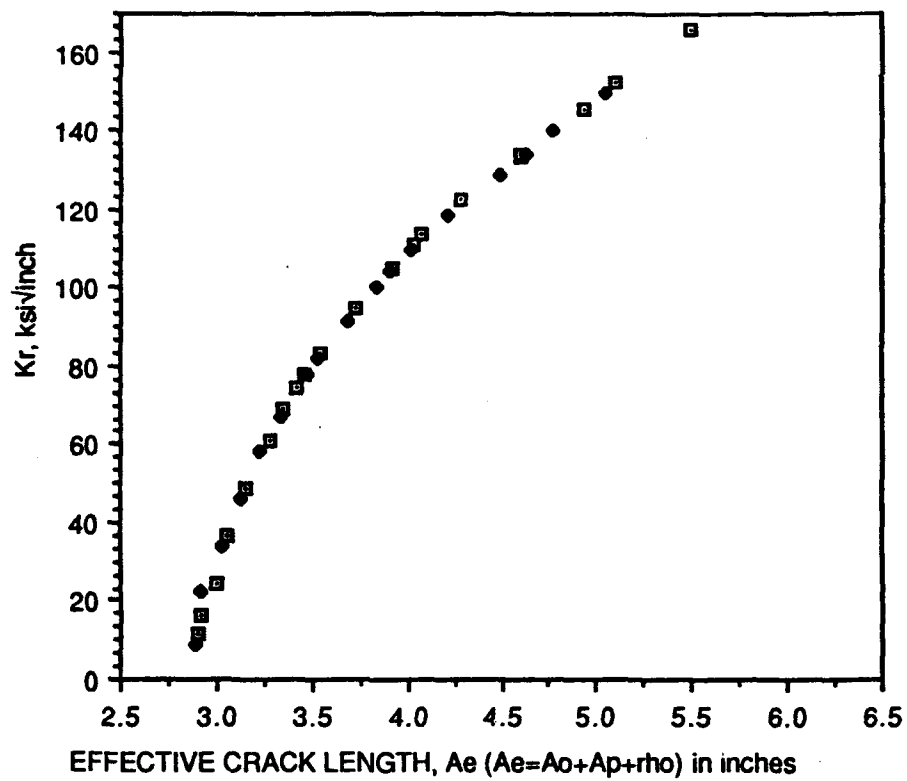


Figure K4. R-Curve Results for 2091-T3
0.144 Inch Sheet with Effective Crack Length
Adjusted for Plastic Zone (T-L Orientation)
Martin Marietta.

TABLE K16
R-CURVE DATA ASSOCIATED WITH
FIGURES K1 AND K3 (SPECIMEN 3)

Load, kips	Half Crack Length (c) inch	Half Crack Length, (c + rho) inch	Corresponding Fracture Toughness, ksi $\sqrt{\text{inch}}$	
			Not adjusted	Adjusted for Plasticity
10	3.895	3.902	11	11
18	3.960	3.985	20	20
24	3.960	4.004	26	26
26	3.975	4.029	29	29
28	3.990	4.053	31	31
29	3.990	4.059	32	33
32	4.000	4.083	36	36
36	4.020	4.126	40	41
40	4.020	4.154	45	46
44	4.020	4.183	49	50
48	4.020	4.213	53	55
52	4.020	4.251	58	60
57	4.020	4.295	63	65
61	4.020	4.340	68	70
64	4.045	4.402	71	74
65	4.060	4.451	73	78
67	4.085	4.497	75	80
69	4.085	4.525	77	83
71	4.105	4.581	80	86
71	4.115	4.601	80	87
74	4.140	4.668	84	91
74	4.140	4.677	84	91
76	4.165	4.732	86	94
76	4.225	4.812	88	95
76	4.225	4.823	88	96
78	4.255	4.886	90	99
80	4.290	4.967	93	103
81	4.325	5.027	94	104
82	4.500	5.284	99	110
82	4.655	5.495	102	114
83	4.750	5.649	104	118
82	4.900	5.837	105	121
82	5.045	6.042	108	124
81	5.345	6.447	112	131

Thickness = .144 inch
Yield = 49.7 ksi
Specimen Width = 23.83 inch

TABLE K17
R-CURVE DATA ASSOCIATED WITH
FIGURES K1 AND K3 (SPECIMEN 4)

Load, kips	Half Crack Length (c) inch	Half Crack Length, (c + rho) inch	Corresponding Fracture Toughness, ksi $\sqrt{\text{inch}}$	
			Not adjusted	Adjusted for Plasticity
10	3.895	3.902	11	11
19	3.895	3.924	21	21
28	3.895	3.956	31	31
36	3.930	4.032	39	40
44	4.000	4.163	49	50
52	4.000	4.231	58	60
60	4.010	4.319	67	69
65	4.040	4.416	73	76
69	4.080	4.523	77	83
74	4.110	4.641	84	91
78	4.200	4.823	90	98
79	4.260	4.921	92	101
80	4.350	5.058	95	105
82	4.480	5.262	99	110
84	4.575	5.440	102	116
84	4.615	5.492	102	117
84	4.735	5.663	105	120
84	4.800	5.754	106	122
84	4.890	5.883	107	124
84	4.945	5.956	107	125
84	5.025	6.072	109	128
84	5.135	6.223	111	130
82	5.320	6.435	111	132
81	5.490	6.661	114	135
79	5.730	6.962	115	138
74.5	6.265	7.660	117	144
74.5	6.440	7.932	118	152

Thickness = .144 inch
Yield = 49.7 ksi
Specimen Width = 23.81 inch

TABLE K18
R-CURVE DATA ASSOCIATED WITH
FIGURES K2 AND K4 (SPECIMEN 1)

Load, kips	Half Crack Length (c) inch	Half Crack Length, (c + rho) inch	Corresponding Fracture Toughness, ksi $\sqrt{\text{inch}}$	
			Not adjusted	Adjusted for Plasticity
10	2.895	2.905	12	12
13	2.895	2.915	16	16
19	2.950	2.995	24	25
28	2.960	3.061	36	36
37	2.980	3.158	47	49
46	2.995	3.279	58	61
50	2.995	3.354	64	69
54	3.000	3.422	69	75
56	3.005	3.461	71	78
59	3.020	3.547	75	83
65	3.045	3.728	83	95
69	3.085	3.920	89	105
71	3.100	4.032	92	111
72	3.100	4.077	94	114
75	3.150	4.282	98	122
76	3.250	4.598	102	133
77	3.250	4.608	102	134
78	3.345	4.943	106	145
79	3.355	5.104	108	152
79	3.420	5.500	110	166
79	3.525		112	
77	3.655		113	
75	3.865		113	
71	4.100		113	

Thickness = .144 inch
 Yield = 45.9 ksi
 Specimen Width = 18.03 inch

TABLE K19
R-CURVE DATA ASSOCIATED WITH
FIGURES K2 AND K4 (SPECIMEN 2)

Load, kips	Half Crack Length (c) inch	Half Crack Length, (c + rho) inch	Corresponding Fracture Toughness, ksi $\sqrt{\text{inch}}$	
			Not adjusted	Adjusted for Plasticity
8	2.880	2.886	10	9
18	2.880	2.918	22	22
26	2.950	3.036	33	34
36	2.950	3.122	45	46
44	2.975	3.231	56	58
49	2.990	3.331	63	67
56	3.020	3.477	71	78
58	3.025	3.530	74	82
63	3.050	3.687	81	92
67	3.075	3.837	86	100
68	3.080	3.901	88	104
70	3.115	4.025	92	110
73	3.150	4.214	96	119
75	3.240	4.499	101	129
76	3.260	4.627	103	134
78	3.275	4.766	105	140
78	3.365	5.054	107	149
79	3.425		110	
79	3.425		110	
78	3.540		112	
78	3.605		112	
76	3.735		112	
75	3.865		115	
73	3.940		113	
74	3.955		114	
73	4.000		114	

Thickness = .144 inch
Yield = 45.9 ksi
Specimen Width = 18.01 inch

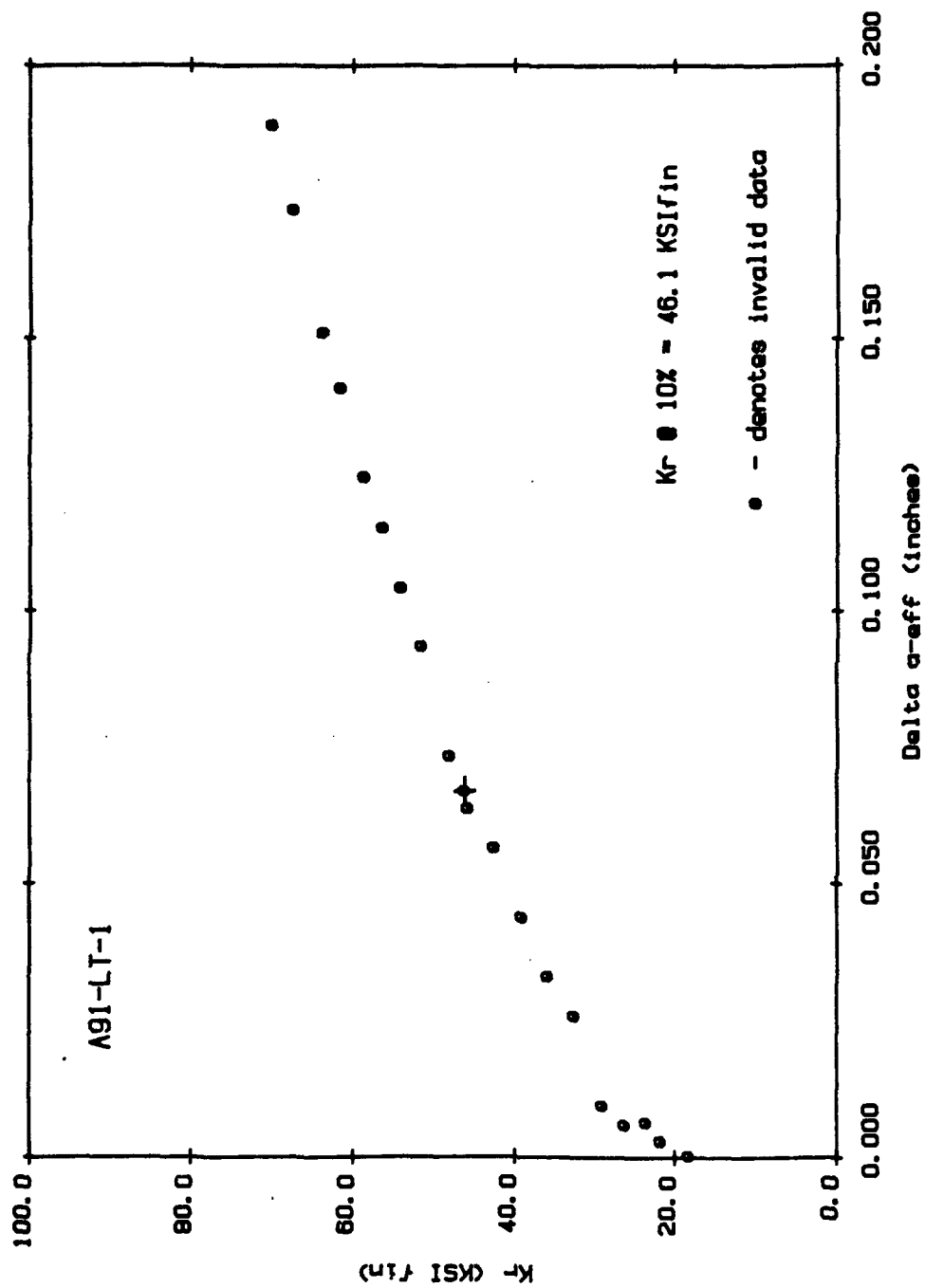


FIGURE K5. R-CURVE RESULTS FOR 2091-T3 0.144 INCH SHEET (L-T ORIENTATION). AIR FORCE.

R-CURVE DATA ASSOCIATED WITH

FIGURE K5 (L-T ORIENTATION)

A91-LT-1 Oct 7, 1988

W = 2.509 inches

2.303 inches
0.143 inches

0.143 inches
E = 12.760 MSI

E = 12.760 MSI
YS = 51.000 KSI

YS = 31,000 KSI
Initial a (physical) = 1.046 inches

Initial a (buysical) = 1.046 inches
Initial a (compliance) = 1.044 inches

POINT	2V	P (LBF)	EB2V/P	a-eff/W	Kr	a-eff	delta a
1	***	Initial compliance	crack length ***			1.0436	
1	0.0116	542	42.57	0.4160	18.22	1.0438	0.0003
2	0.0140	645	42.74	0.4171	21.74	1.0465	0.0030
3	0.0153	696	42.95	0.4185	23.57	1.0500	0.0064
4	0.0172	775	42.92	0.4183	26.22	1.0495	0.0060
5	0.0191	854	43.14	0.4197	29.01	1.0530	0.0095
6	0.0218	942	44.17	0.4262	32.57	1.0694	0.0258
7	0.0241	1029	44.64	0.4291	35.87	1.0767	0.0331
8	0.0265	1109	45.34	0.4334	39.10	1.0874	0.0438
9	0.0292	1192	46.21	0.4385	42.61	1.1002	0.0566
10	0.0315	1271	46.70	0.4413	45.79	1.1074	0.0638
11	0.0333	1321	47.37	0.4452	48.13	1.1170	0.0734
12	0.0360	1384	48.82	0.4532	51.57	1.1371	0.0935
13	0.0380	1434	49.62	0.4575	54.00	1.1479	0.1043
14	0.0398	1475	50.46	0.4619	56.34	1.1589	0.1153
15	0.0416	1518	51.19	0.4656	58.59	1.1683	0.1247
16	0.0440	1564	52.51	0.4722	61.52	1.1847	0.1411
17	0.0459	1603	53.35	0.4762	63.81	1.1949	0.1513
18	0.0490	1651	55.26	0.4851	67.47	1.2172	0.1736
19	0.0512	1682	56.64	0.4913	70.04	1.2326	0.1890
20	0.0565	1738	60.36	0.5068	75.90	1.2717	0.2281
21	0.0597	1762	62.84	0.5165	79.32	1.2959	0.2523
22	0.0660	1792	63.12	0.5353	85.79	1.3430	0.2994
23	0.0318	1275	46.92	0.4426	46.10	1.1105	0.0670

The following value is the 10% SECANT value

The following value is the 10% SECANT value

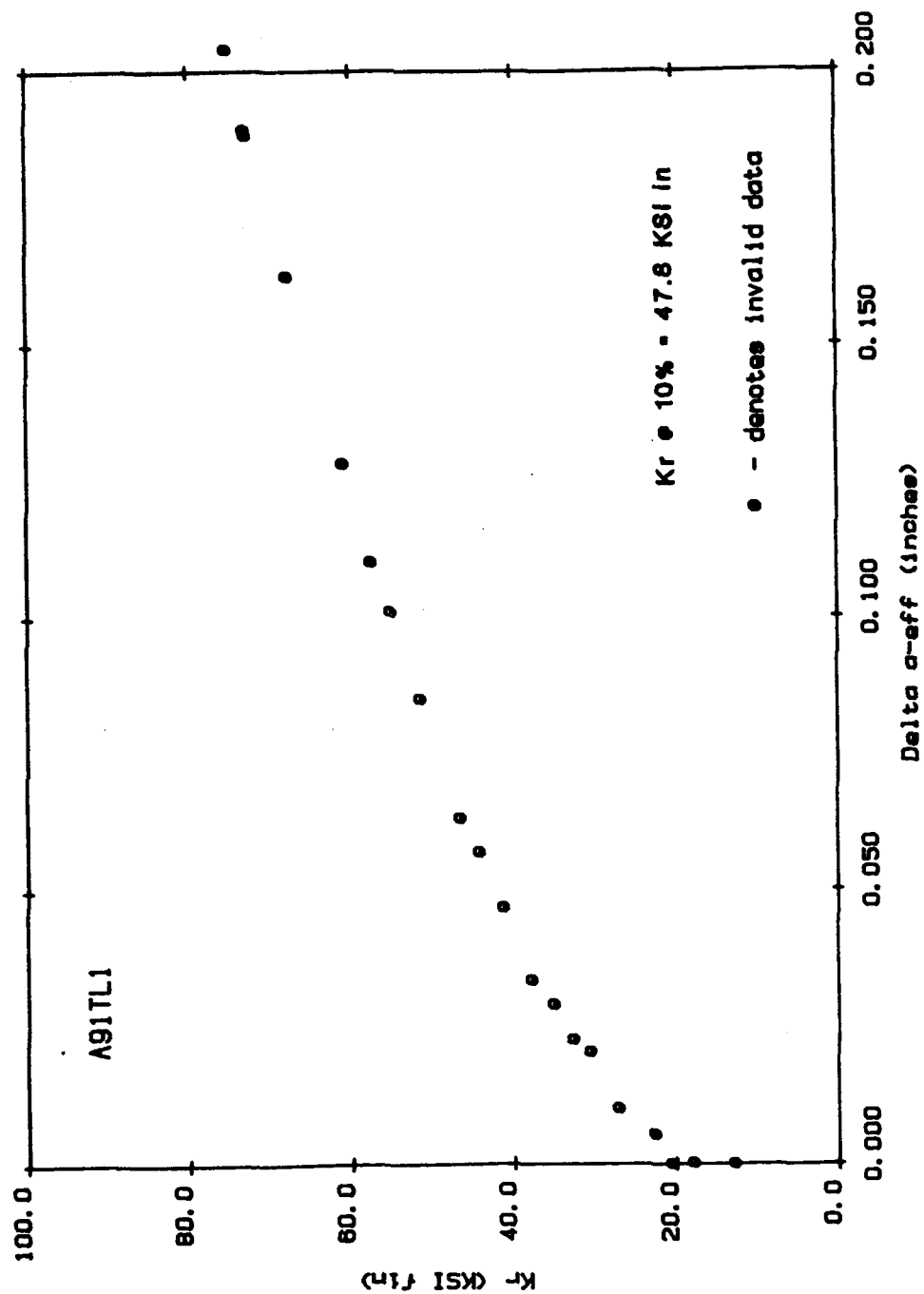


FIGURE K6. R-CURVE RESULTS FOR 2091-T3
0.144 INCH SHEET (T-L Orientation).
AIR FORCE.

R-CURVE DATA ASSOCIATED WITH

FIGURE K6 (T-L ORIENTATION)

The following value is the 10% SECANT value

0.0339	1314	47.48	0.4458
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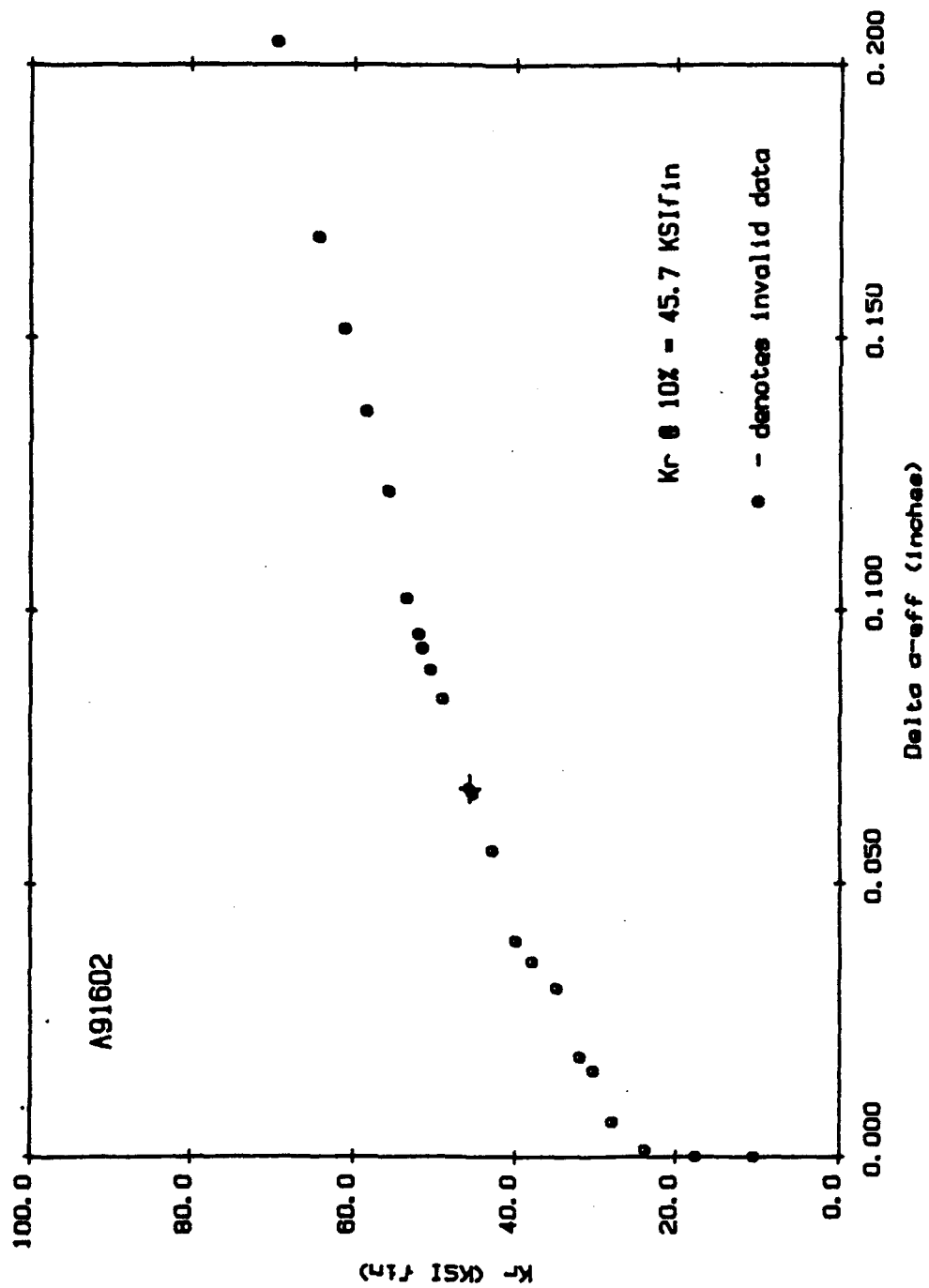


FIGURE K7. R-CURVE RESULTS for 2091-T3 0.144 Inch Sheet
(60° Orientation, Specimen 1).
Air Force.

R-CURVE DATA ASSOCIATED WITH

FIGURE K7 (60° ORIENTATION, SPECIMEN 1)

W = 2.506 inches

W = 2.506 inches

B = 0.143 inches

E = 12.450 MSI

YS = 50.00 KSI

Initial a (physical) = 1.109 inches

Initial a (compliance) = 1.106 inches
Initial b (compliance) = 1.109 inches

POINT	2V	P (LBF)	EB2V/P	a-eff/W	Kr	a-eff	delta a
1	***	initial compliance	crack length ***			1.1065	
1	0.0063	292	46.08	0.4378	10.39	1.0968	-0.0097
2	0.0115	489	46.35	0.4393	17.49	1.1007	-0.0058
3	0.0161	656	46.83	0.4421	23.66	1.1077	0.0012
4	0.0190	764	47.19	0.4442	27.70	1.1129	0.0064
5	0.0209	821	47.86	0.4479	30.10	1.1222	0.0157
6	0.0222	866	48.04	0.4489	31.82	1.1247	0.0183
7	0.0244	930	48.95	0.4539	34.68	1.1372	0.0307
8	0.0268	1011	49.31	0.4558	37.87	1.1420	0.0355
9	0.0283	1060	49.59	0.4573	39.89	1.1454	0.0393
10	0.0307	1116	50.86	0.4639	42.82	1.1623	0.0558
11	0.0327	1168	51.64	0.4641	45.34	1.1728	0.0663
12	0.0357	1238	53.10	0.4750	49.03	1.1902	0.0837
13	0.0377	1284	53.89	0.4788	51.45	1.1996	0.0931
14	0.0369	1266	53.55	0.4772	50.47	1.1955	0.0890
15	0.0381	1293	54.11	0.4798	51.93	1.2021	0.0956
16	0.0394	1321	54.67	0.4824	53.48	1.2087	0.1022
17	0.0414	1343	56.42	0.4903	55.69	1.2284	0.1219
18	0.0437	1384	57.76	0.4961	58.41	1.2430	0.1365
19	0.0461	1422	59.20	0.5021	61.10	1.2580	0.1516
20	0.0488	1463	60.86	0.5088	64.21	1.2749	0.1684
21	0.0536	1508	64.64	0.5231	69.27	1.3106	0.2042
22	0.0605	1530	71.77	0.5471	76.10	1.3706	0.2642
23	0.0680	1515	81.30	0.5741	82.92	1.4384	0.3319
24	0.0330	1175	51.76	0.4684	45.67	1.1737	0.0672

The following value is the 10% SECANT value

'The following value is the 10% SECANT' value

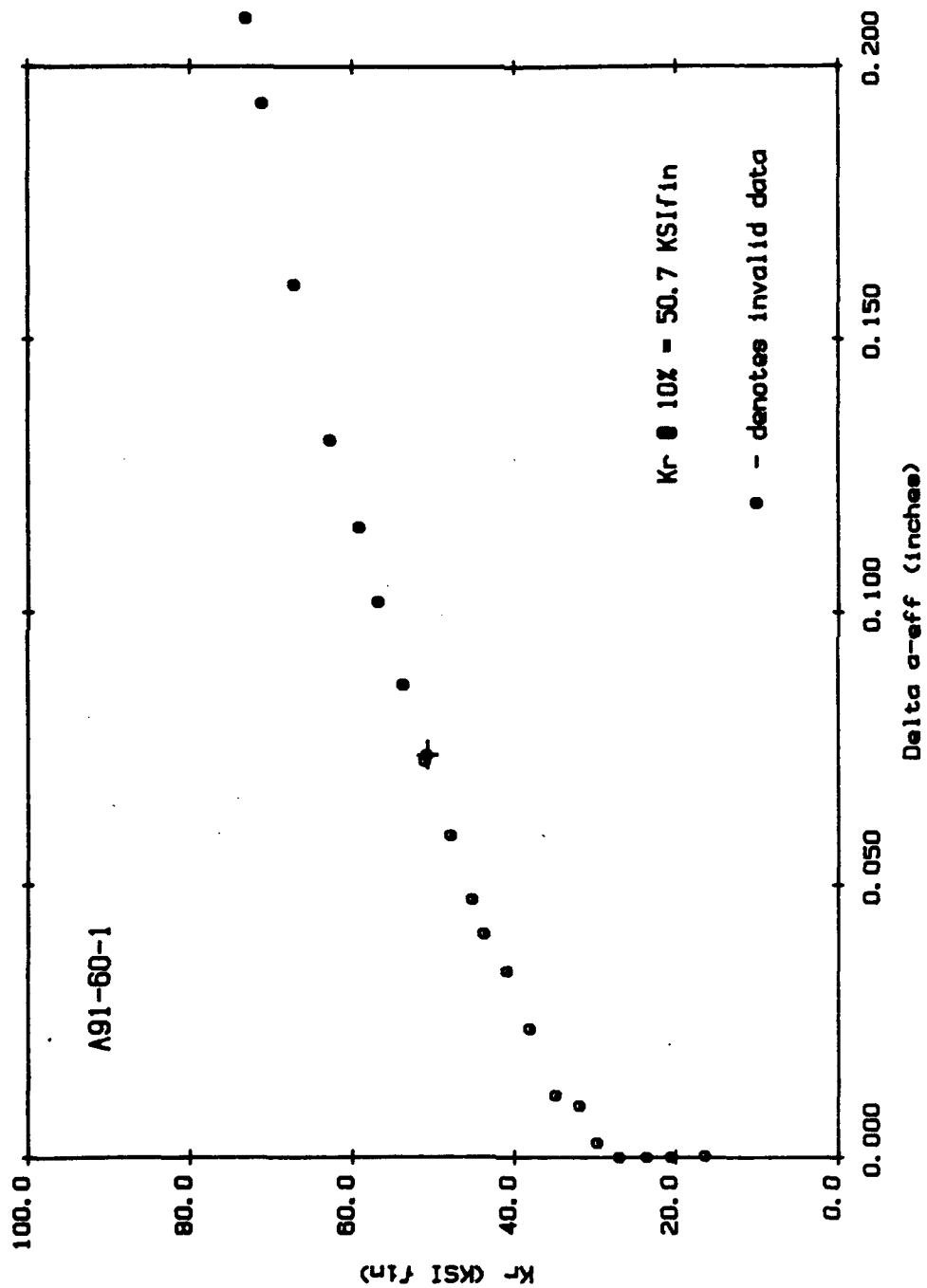


FIGURE K8. R-CURVE RESULTS FOR 2091-T3
0.144 INCH SHEET (60° ORIENTATION,
SPECIMEN 2). AIR FORCE

TABLE K23

R-CURVE DATA ASSOCIATED WITH FIGURE K8
(60° ORIENTATION, SPECIMEN 2)

A91-60-1 Oct 7, 1988

W = 2.508 inches

B = 0.143 inches

E = 11.980 MSI

YS = 50.000 KSI

Initial a (physical) = 1.036 inches

Initial a (compliance) = 1.034 inches

POINT	2V	P (LBF)	EB _{2V} /P	a-eff/W	B/	a-eff	delta a
1	***	initial compliance	crack length ***			1.0343	
1	0.0106	493	42.05	0.4125	16.32	1.0346	0.0002
2	0.0136	622	41.66	0.4099	20.46	1.0280	-0.0063
3	0.0159	709	42.03	0.4124	23.49	1.0342	-0.0001
4	0.0184	815	41.84	0.4112	26.92	1.0311	-0.0032
5	0.0205	893	42.19	0.4135	29.67	1.0369	0.0026
6	0.0222	952	42.60	0.4162	31.86	1.0438	0.0095
7	0.0244	1038	42.72	0.4170	34.80	1.0457	0.0114
8	0.0269	1119	43.48	0.4218	38.03	1.0579	0.0236
9	0.0291	1189	44.15	0.4261	40.85	1.0685	0.0342
10	0.0313	1263	44.59	0.4288	43.73	1.0753	0.0410
11	0.0325	1294	45.00	0.4313	45.13	1.0816	0.0473
12	0.0346	1354	45.77	0.4359	47.80	1.0933	0.0590
13	0.0372	1421	46.71	0.4414	50.96	1.1070	0.0727
14	0.0394	1472	47.69	0.4470	53.60	1.1210	0.0867
15	0.0421	1533	48.80	0.4531	56.77	1.1362	0.1019
16	0.0441	1570	49.82	0.4585	59.09	1.1499	0.1156
17	0.0471	1636	51.05	0.4649	62.66	1.1658	0.1315
18	0.0512	1696	53.35	0.4762	67.17	1.1943	0.1600
19	0.0550	1725	56.24	0.4895	71.07	1.2276	0.1933
20	0.0569	1740	57.68	0.4957	73.03	1.2432	0.2089
21	0.0771	1765	76.54	0.5612	91.85	1.4074	0.3731
22	The following value is the 10% SECANT value						
	0.0370	1411	46.79	0.4419	50.66	1.1081	0.0738

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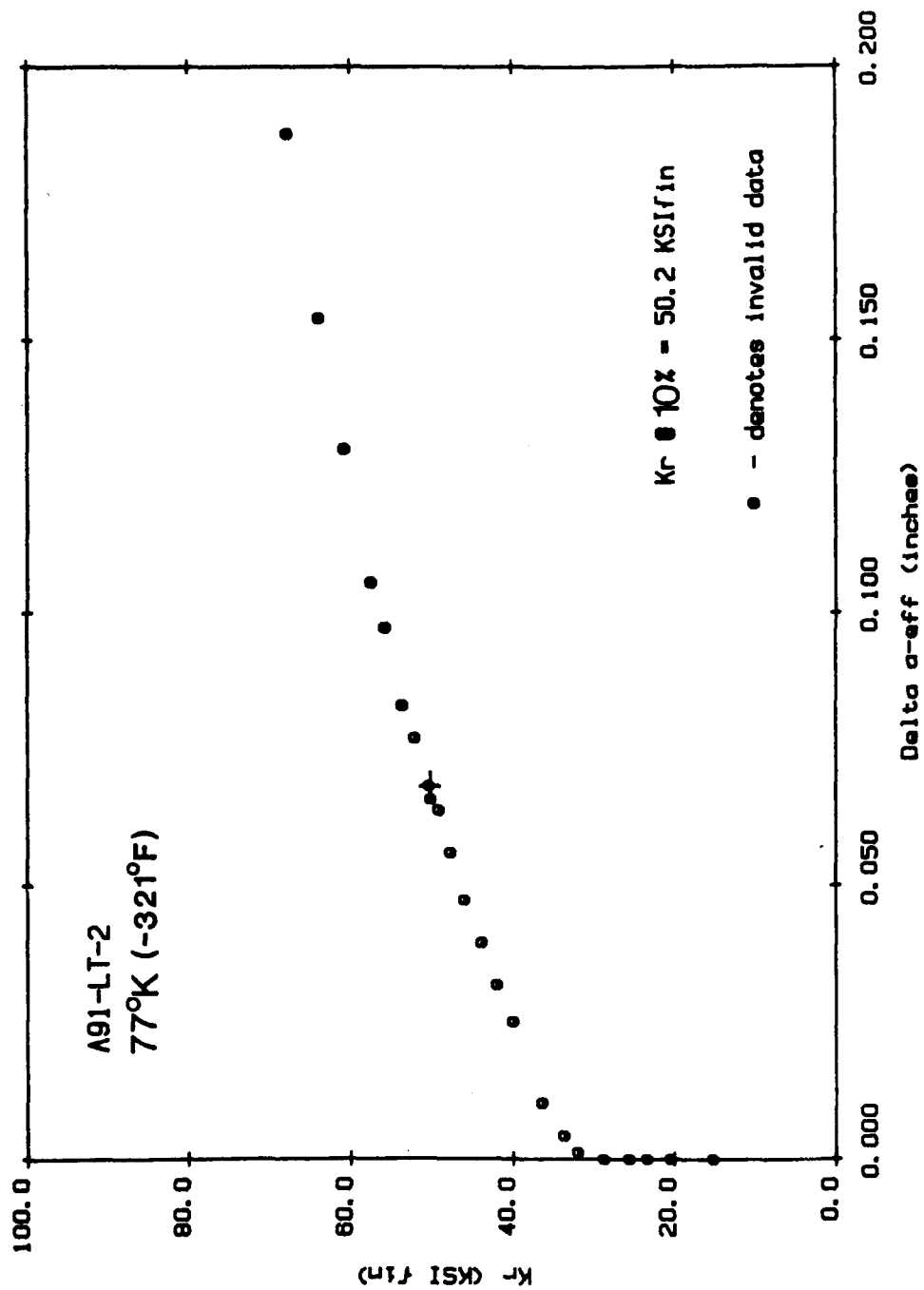


FIGURE K9. R-CURVE RESULTS FOR 2091-T3
0.144 INCH SHEET (L-T ORIENTATION,
-321°F). AIR FORCE.

TABLE K24

R-CURVE DATA ASSOCIATED WITH FIGURE K9
(L-T ORIENTATION, 321°F)

A91-LT-2 7 Oct, 1988

W = 2.501 inches

B = 0.144 inches

E = 13.690 MSI

YS = 51.000 KSI

Initial a (physical) = 1.031 inches

Initial a (compliance) = 1.029 inches

POINT	2V	P (LBF)	EB2V/P	a-eff/W	Kr	a-eff	delta a
1	0.0074	597	42.35	0.4146	12.89	1.0287	0.0000
2	0.0088	460	41.75	0.4105	15.15	1.0266	-0.0021
3	0.0121	624	41.34	0.4078	20.38	1.0197	-0.0089
4	0.0140	708	41.69	0.4102	23.27	1.0257	-0.0030
5	0.0154	778	41.47	0.4087	25.49	1.0219	-0.0067
6	0.0175	872	41.62	0.4097	28.64	1.0244	-0.0043
7	0.0196	965	41.94	0.4118	31.89	1.0299	0.0012
8	0.0207	1014	42.12	0.4130	33.59	1.0328	0.0042
9	0.0225	1089	42.49	0.4154	36.32	1.0389	0.0102
10	0.0250	1178	43.40	0.4214	39.91	1.0537	0.0251
11	0.0264	1228	43.83	0.4241	41.91	1.0604	0.0318
12	0.0277	1272	44.33	0.4272	43.81	1.0682	0.0396
13	0.0292	1323	44.84	0.4303	45.93	1.0761	0.0474
14	0.0304	1359	45.41	0.4338	47.65	1.0848	0.0561
15	0.0314	1387	45.94	0.4369	49.05	1.0925	0.0639
16	0.0321	1412	46.07	0.4377	50.04	1.0945	0.0659
17	0.0335	1449	46.85	0.4422	52.01	1.1058	0.0771
18	0.0346	1481	47.27	0.4446	53.50	1.1117	0.0831
19	0.0362	1515	48.29	0.4503	55.61	1.1260	0.0973
20	0.0375	1550	48.89	0.4536	57.43	1.1342	0.1056
21	0.0402	1594	50.76	0.4634	60.74	1.1587	0.1301
22	0.0427	1630	52.67	0.4729	63.84	1.1826	0.1540
23	0.0459	1660	55.56	0.4865	67.66	1.2164	0.1878
24	0.0491	1678	58.69	0.5000	71.29	1.2504	0.2217
25	0.0548	1678	65.36	0.5257	77.31	1.3146	0.2859
26	0.0564	1651	68.39	0.5362	78.74	1.3408	0.3121
The following value is the 10% SECANT value							
27	0.0322	1412	46.24	0.4367	50.17	1.0970	0.0683

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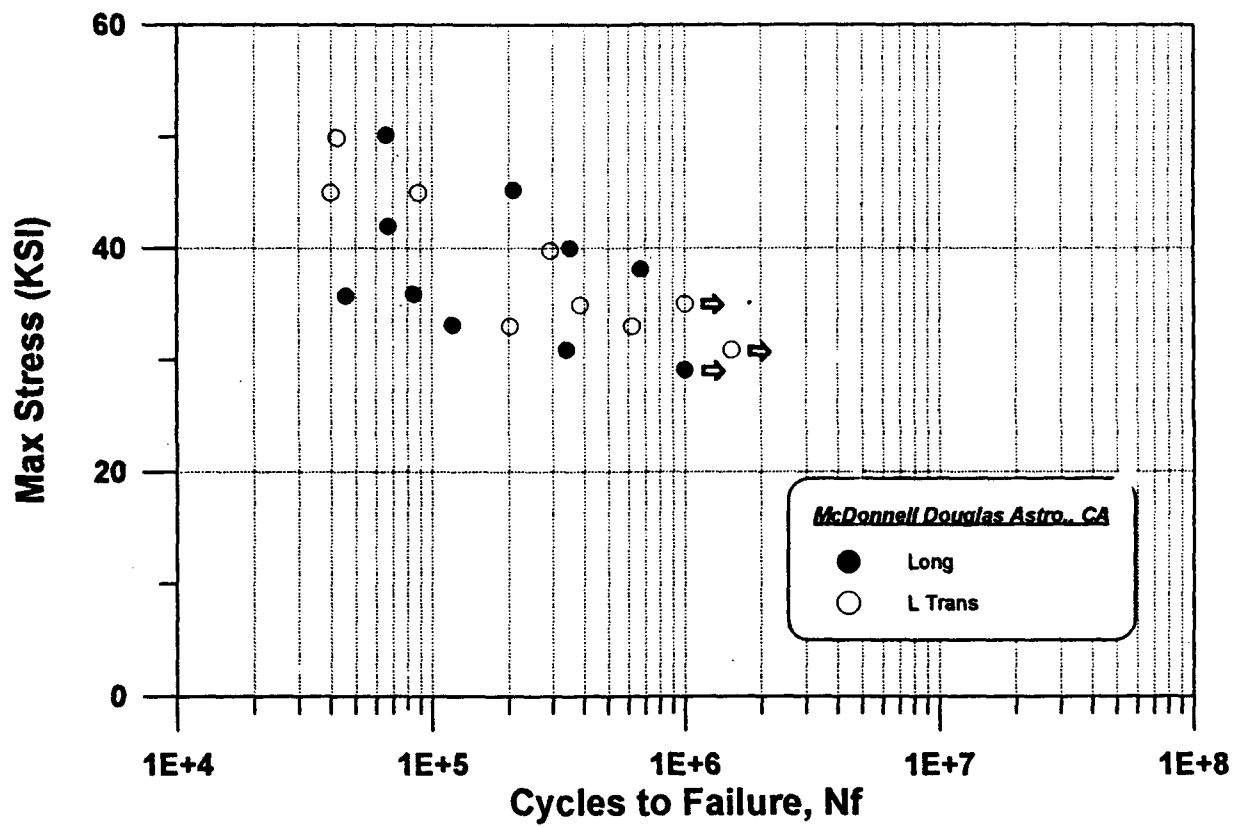


FIGURE K10. FATIGUE RESULTS FOR 2091-T3
0.144 INCH SHEET ($R=1.0$, $K_t \approx 1.0$).
MCDONNELL DOUGLAS ASTRONAUTICS

TABLE K25

FATIGUE RESULTS WITH R=0.1 AND Kt=1.0 FOR
ALCOA 2091-T3 SHEET (0.144" X 48" X 48")

COMPANY	ORIENTATION	STRESS (KSI)	CYCLES
MCDONNELL DOUGLAS	LONG	50.2	65,600 +
ASTRO., CA		45.2	209,000 +
		42.0	67,000
		40.0	353,000 +
		38.1	670,000 +
		35.9	84,400 @
		35.7	45,700 #
		33.1	120,000 @
		30.9	340,000
		29.1	1,000,000 *

(*): INDICATES A RUN-OUT TEST
 (#): INDICATES FAILURE AT PIN HOLE
 (@): INDICATES FAILURE AT RADIUS
 (+): INDICATES SPECIMENS WERE RECONFIGURED AND
 HAD SURFACE COATING REMOVED

TABLE K26

FATIGUE RESULTS WITH R=0.1 AND Kt=1.0 FOR
ALCOA 2091-T3 SHEET (0.144" X 48" X 48")

COMPANY	ORIENTATION	STRESS (KSI)	CYCLES
MCDONNELL DOUGLAS	L TRANS	49.9	42,300 +
ASTRO., CA		45.0	87,700 #+
		45.0	39,900
		39.8	293,000 +
		35.0	1,000,000 **
		34.9	385,000 !
		33.0	203,000 !
		33.0	621,000 !
		30.9	1,530,000 *!

(*): INDICATES A RUN-OUT TEST
 (#): INDICATES FAILURE AT PIN HOLE
 (!): INDICATES THE SPECIMENS WERE ONLY RECONFIGURED
 (+): INDICATES SPECIMENS WERE RECONFIGURED AND
 HAD SURFACE COATING REMOVED

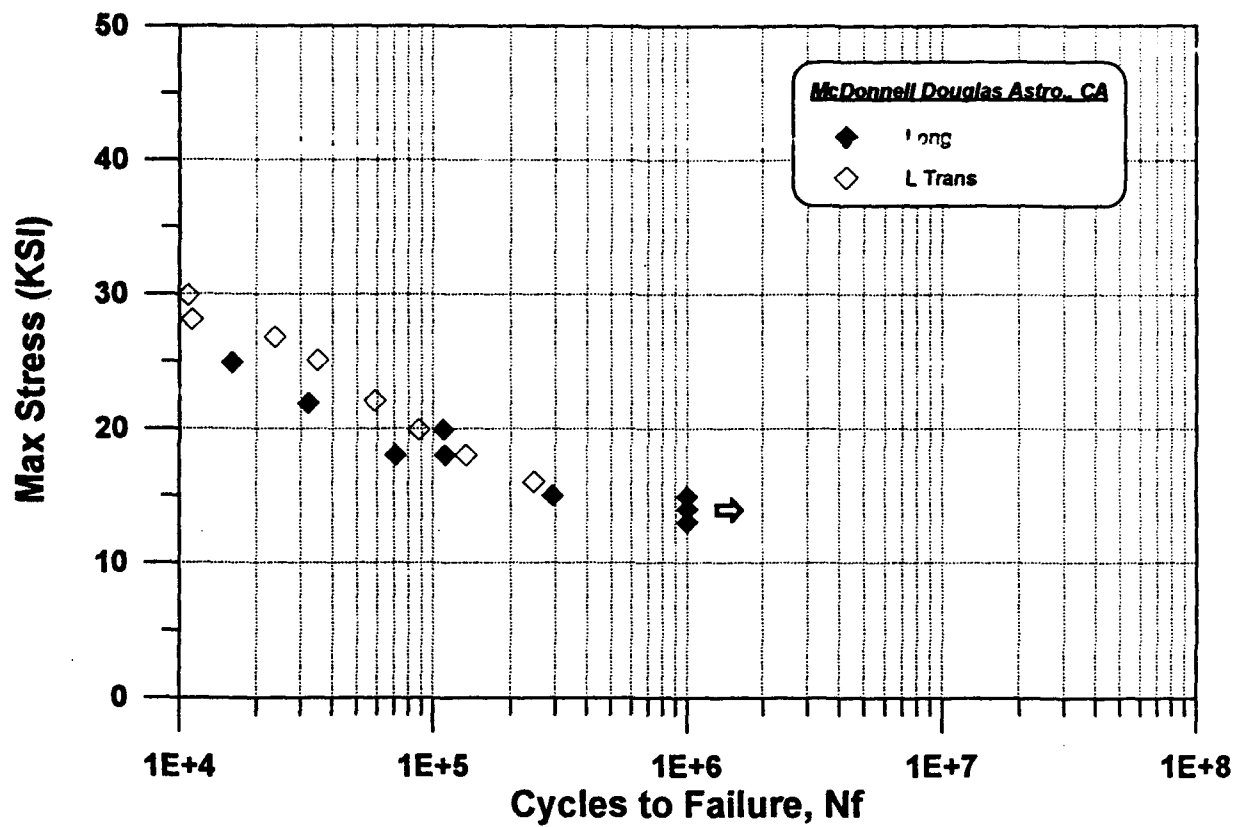


FIGURE K11. FATIGUE RESULTS FOR 2091-T3
0.144 INCH SHEET ($R=1.0$, $K_t=3.0$).
MCDONNELL DOUGLAS ASTRONAUTICS

TABLE K27

FATIGUE RESULTS WITH R=0.1 AND Kt=3.0 FOR
ALCOA 2091-T3 SHEET (0.144" X 48" X 48")

COMPANY	ORIENTATION	STRESS (KSI)	CYCLES
MCDONNELL DOUGLAS	LONG	24.9	16,100
ASTRO., CA		21.9	32,200
		19.9	109,000
		18.0	112,000
		18.0	71,250
		15.0	294,000
		14.9	1,000,000 *
		14.0	1,000,000 *
		13.0	1,000,000 *

(*): INDICATES A RUN-OUT TEST

TABLE K28

FATIGUE RESULTS WITH R=0.1 AND Kt=3.0 FOR
ALCOA 2091-T3 SHEET (0.144" X 48" X 48")

COMPANY	ORIENTATION	STRESS (KSI)	CYCLES
MCDONNELL DOUGLAS	L TRANS	29.9	10,800
ASTRO., CA		28.1	11,200
		26.8	23,700
		25.1	34,900
		22.1	58,700
		19.9	87,400
		18.0	135,000
		16.0	247,000
		14.9	1,000,000

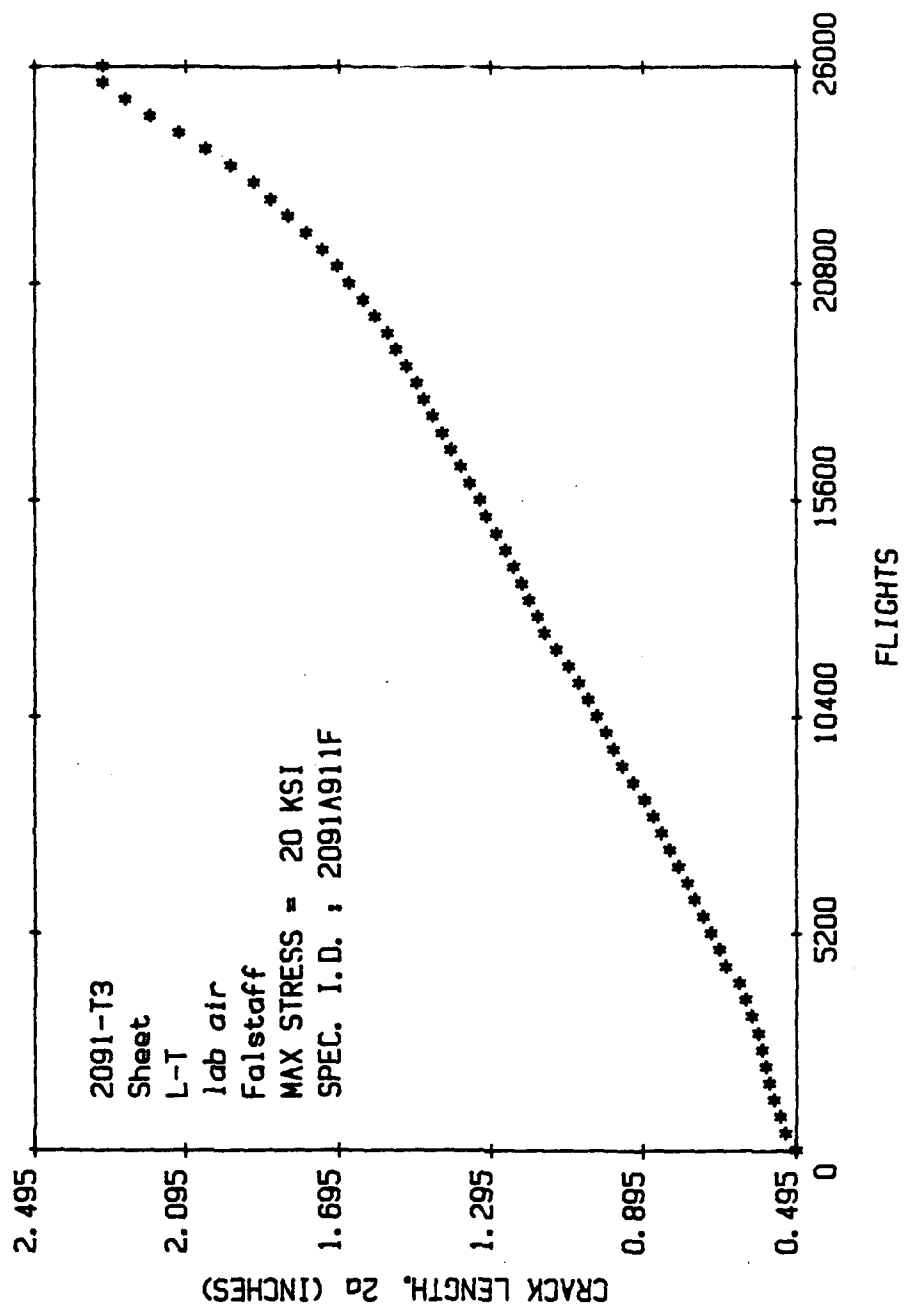


FIGURE K12. FALSTAFF SPECTRUM FATIGUE CRACK LENGTH
VS FLIGHTS DATA FOR 2091-T3 0.144
INCH SHEET, AIR FORCE.

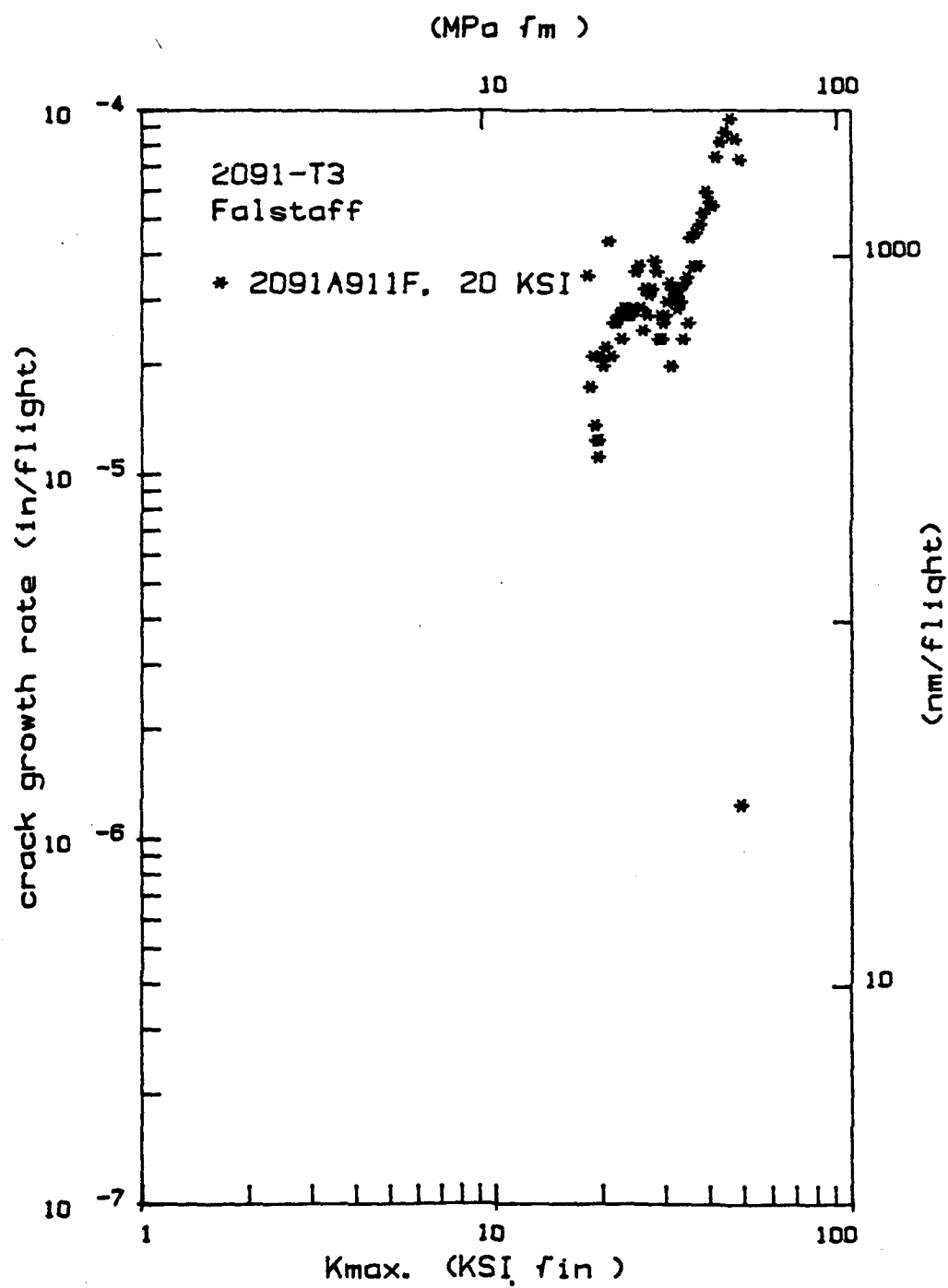


FIGURE K13. FALSTAFF SPECTRUM FATIGUE CRACK
 GROWTH RATE VS KMAX DATA FOR
 2091-T3 0.144 INCH SHEET.
 AIR FORCE.

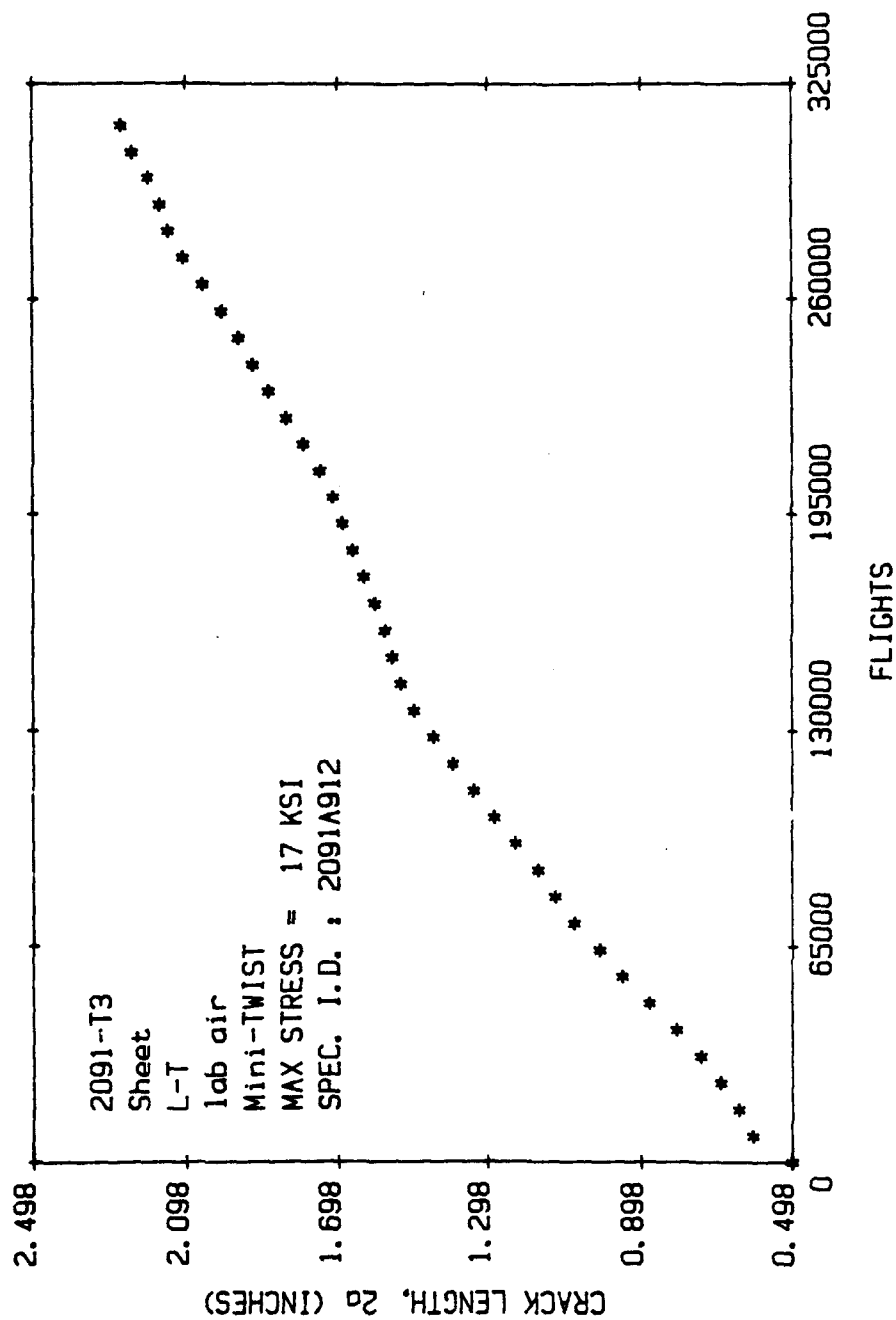


FIGURE K14. MINI-TWIST SPECTRUM FATIGUE CRACK LENGTH
VS FLIGHTS DATA FOR 2091-T3 0.144
INCH SHEET(SPECIMEN #2091A912)

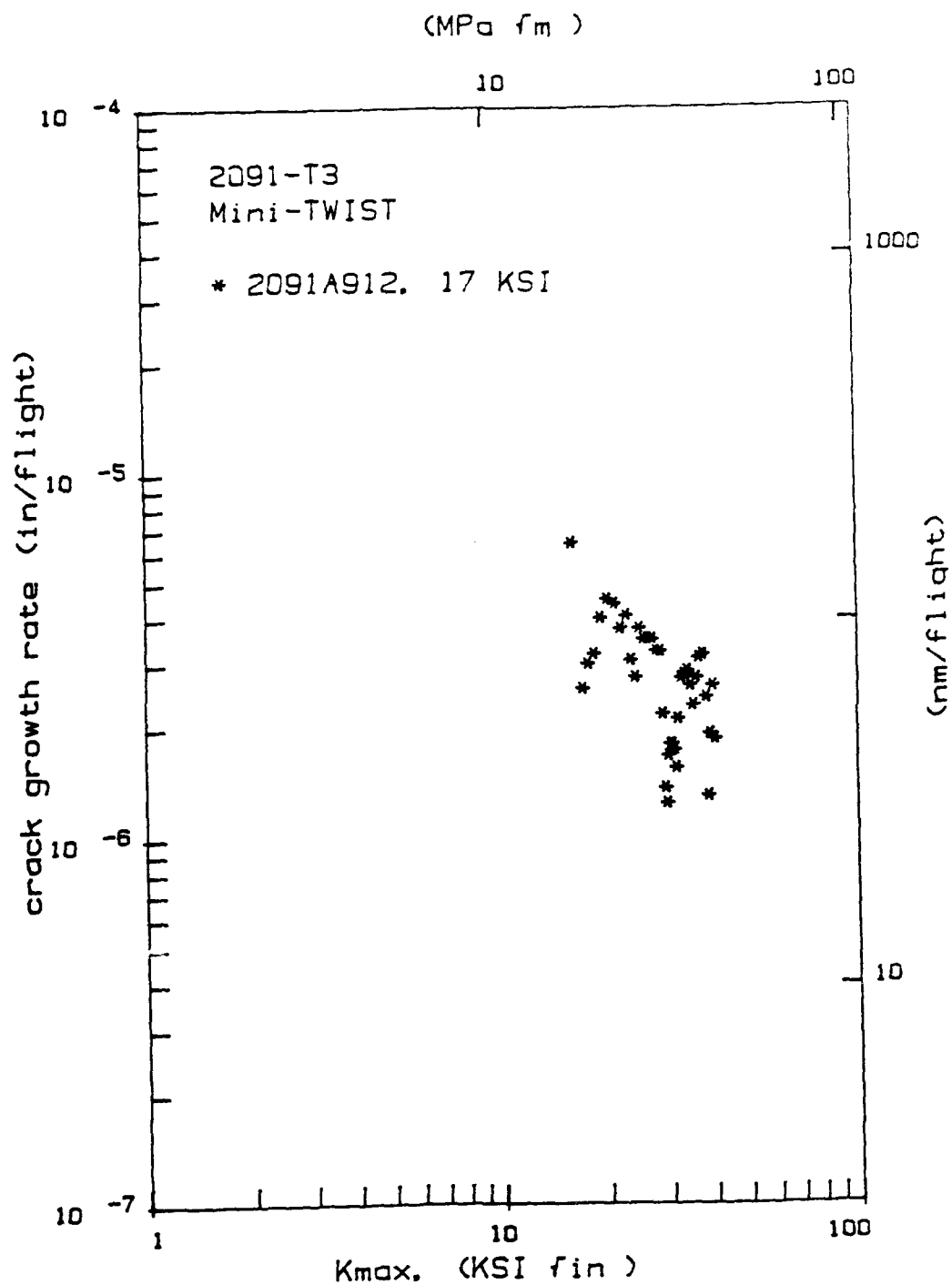


FIGURE K15. MINI-TWIST SPECTRUM CRACK GROWTH RATE
VS KMAX DATA FOR 2091-T3
0.144 INCH SHEET
(Specimen #2091A912).
AIR FORCE.

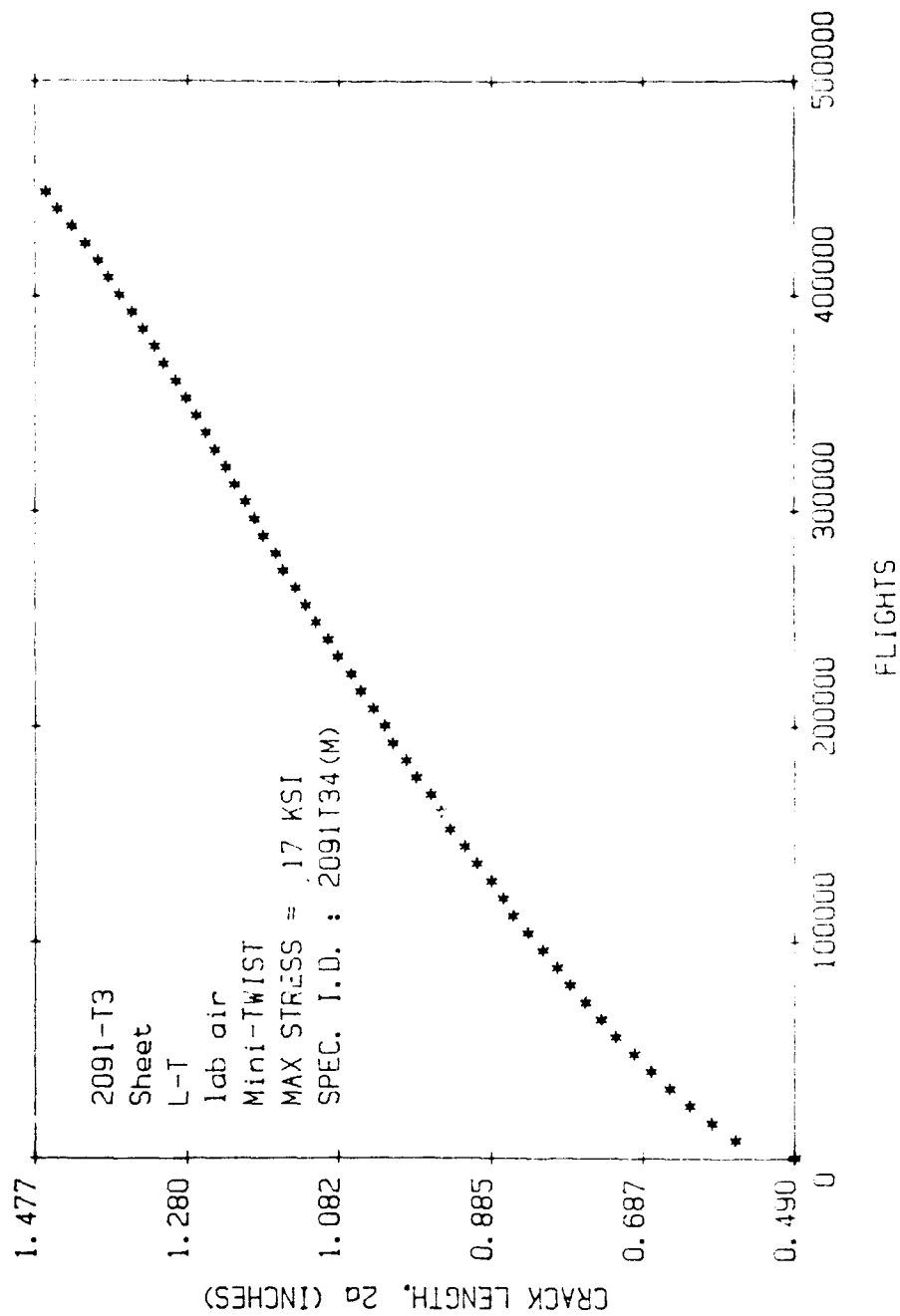


FIGURE K16 MINI-TWIST SPECTRUM FATIGUE CRACK LENGTH
VS FLIGHTS DATA FOR 2091-T3 0 144
INCH SHEET(SPECIMEN #2091T34M).
AIR FORCE

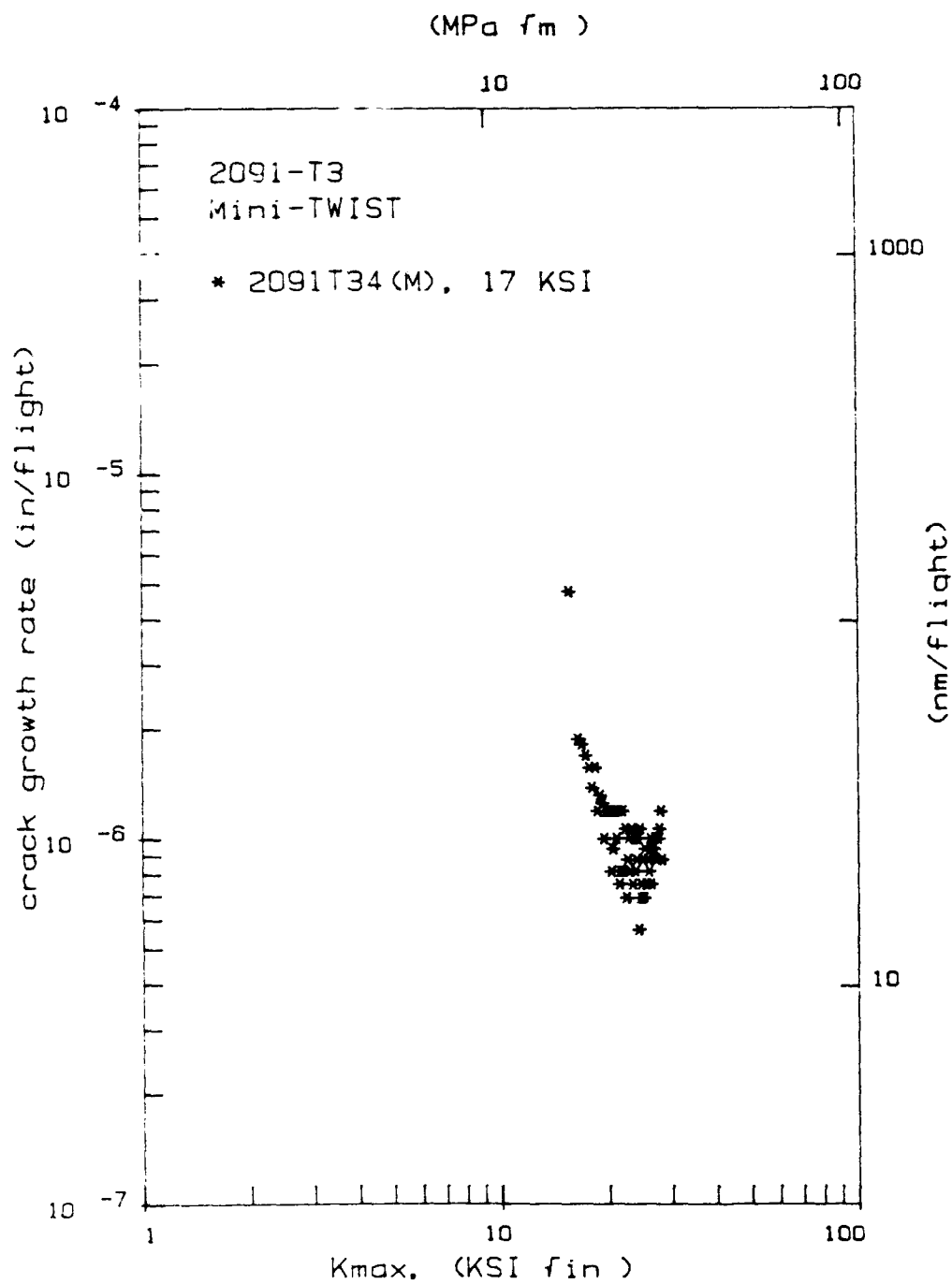


FIGURE K17. MINI-TWIST SPECTRUM CRACK GROWTH
 RATE VS KMAX DATA FOR 2091-T3
 0.144 INCH SHEET (SPECIMEN #2091T34M).
 AIR FORCE.

TABLE K29

TENSILE RESULTS FOR ALCOA

2091-T3 SHEET (0.144" X 48" X 48")

AGED 16 HOURS AT 335 F

COMPANY	TEST TEMP (DEGREES F)	ORIENT- ATION	ULTIMATE STRENGTH (KSI)	YIELD STRENGTH (KSI)	ELONG (%)	RA (%)	E (MSI)
GENERAL DYNAMICS, TEXAS	RT	LONG	67.3	56.1	14.2		
			67.1	56.3	14.3		
			AVERAGE			67.2	56.2
	STANDARD DEVIATION			0.1	0.1	0.1	

TABLE K30

TENSILE RESULTS FOR ALCOA

2091-T3 SHEET (0.144" X 48" X 48")

AGED 16 HOURS AT 335 F

COMPANY	TEST TEMP (DEGREES F)	ORIENT- ATION	ULTIMATE STRENGTH (KSI)	YIELD STRENGTH (KSI)	ELONG (%)	RA (%)	E (MSI)
GENERAL DYNAMICS, TEXAS	RT	45	65.3	46.7	19.2		
			65.6	47.4	19.8		
	AVERAGE		65.5	47.1	19.5		
	STANDARD DEVIATION		0.2	0.5	0.4		

TABLE K31

TENSILE RESULTS FOR ALCOA

2091-T3 SHEET (0.144" X 48" X 48")

AGED 16 HOURS AT 335 F

COMPANY	TEST TEMP (DEGREES F)	ORIENT- ATION	ULTIMATE STRENGTH (KSI)	YIELD STRENGTH (KSI)	ELONG (%)	RA (%)	E (MSI)
GENERAL DYNAMICS, TEXAS	RT	L TRANS	70.7	51.3	12.8		
			70.9	52.8	11.1		
		AVERAGE	70.8	52.1	12.0		
		STANDARD DEVIATION	0.1	1.1	1.2		

TABLE K32

TENSILE RESULTS FOR ALCOA

2091-T3 SHEET (0.144" X 48" X 48")

AGED 32 HOURS AT 335 F

COMPANY	TEST TEMP (DEGREES F)	ORIENT- ATION	ULTIMATE STRENGTH (KSI)	YIELD STRENGTH (KSI)	ELONG (%)	RA (%)	E (MSI)
GENERAL DYNAMICS, TEXAS	RT	LONG	69.6	58.8			
			69.9	59.4	15.3		
	AVERAGE		69.8	59.1	15.3		
	STANDARD DEVIATION		0.2	0.4			

TABLE K33

TENSILE RESULTS FOR ALCOA

2091-T3 SHEET (0.144" X 48" X 48")

AGED 32 HOURS AT 335 F

COMPANY	TEST TEMP (DEGREES F)	ORIENT- ATION	ULTIMATE STRENGTH (KSI)	YIELD STRENGTH (KSI)	ELONG (%)	RA (%)	E (MSI)
GENERAL DYNAMICS, TEXAS	RT	45	68.8	51.9	17.9		
			68.1	51.1	18.5		
	AVERAGE		68.5	51.5	18.2		
	STANDARD DEVIATION		0.5	0.6	0.4		

TABLE K34

TENSILE RESULTS FOR ALCOA

2091-T3 SHEET (0.144" X 48" X 48")

AGED 32 HOURS AT 335 F

COMPANY	TEST TEMP (DEGREES F)	ORIENT- ATION	ULTIMATE STRENGTH (KSI)	YIELD STRENGTH (KSI)	ELONG (%)	RA (%)	E (MSI)
GENERAL DYNAMICS, TEXAS	RT	L TRANS	73.9	57.0	15.6		
			74.5	54.5	14.3		
		AVERAGE	74.2	55.8	15.0		
		STANDARD DEVIATION	0.4	1.8	0.9		

TABLE K35

KAHN TEAR TEST RESULTS FOR ALCOA
2091-T3 SHEET (0.144" X 48" X 48")
AGED 16 HOURS AT 335 F

COMPANY	ORIENTATION	TEAR STRENGTH (KSI)
GENERAL DYNAMICS, TEXAS	L-T	81.4 78.8
AVERAGE		80.1
STANDARD DEVIATION		1.9

TABLE K36

KAHN TEAR TEST RESULTS FOR ALCOA
2091-T3 SHEET (0.144" X 48" X 48")
AGED 16 HOURS AT 335 F

COMPANY	ORIENTATION	TEAR STRENGTH (KSI)
GENERAL DYNAMICS, TEXAS	45-45	74.6
AVERAGE		74.6
STANDARD DEVIATION		

TABLE K37

KAHN TEAR TEST RESULTS FOR ALCOA
2091-T3 SHEET (0.144" X 48" X 48")
AGED 16 HOURS AT 335 F

COMPANY	ORIENTATION	TEAR STRENGTH (KSI)

GENERAL DYNAMICS, TEXAS	T-L	78.2 77.3
AVERAGE		77.7
STANDARD DEVIATION		0.6

TABLE K38

KAHN TEAR TEST RESULTS FOR ALCOA
2091-T3 SHEET (0.144" X 48" X 48")
AGED 32 HOURS AT 335 F

COMPANY	ORIENTATION	TEAR STRENGTH (KSI)

GENERAL DYNAMICS, TEXAS	L-T	76.4
		74.6
AVERAGE		75.5
STANDARD DEVIATION		1.3

TABLE K39

KAHN TEAR TEST RESULTS FOR ALCOA
2091-T3 SHEET (0.144" X 48" X 48")
AGED 32 HOURS AT 335 F

COMPANY	ORIENTATION	TEAR STRENGTH (KSI)
GENERAL DYNAMICS, TEXAS	45-45	73.7 74.1
	AVERAGE	73.9
	STANDARD DEVIATION	0.2

TABLE K40

KAHN TEAR TEST RESULTS FOR ALCOA
2091-T3 SHEET (0.144" X 48" X 48")
AGED 32 HOURS AT 335 F

COMPANY	ORIENTATION	TEAR STRENGTH (KSI)
GENERAL DYNAMICS, TEXAS	T-L	74.7
	AVERAGE	74.7
	STANDARD DEVIATION	

TABLE 41
TEAR-YIELD STRENGTH RATIOS FOR ALCOA
2091-T3 SHEET (0.144" X 48" X 48")
AGED 16 HOURS AT 335 F

COMPANY	TENSILE-TEAR ORIENTATION	TEAR-YIELD STRENGTH RATIO
GENERAL DYNAMICS, TEXAS	L/L-T	1.42
	LT/T-L	1.48
	45/45-45	1.58
	L/T-L	1.38

TABLE 42
TEAR-YIELD STRENGTH RATIOS FOR ALCOA
2091-T3 SHEET (0.144" X 48" X 48")
AGED 32 HOURS AT 335 F

COMPANY	TENSILE-TEAR ORIENTATION	TEAR-YIELD STRENGTH RATIO
GENERAL DYNAMICS, TEXAS	L/L-T	1.27
	LT/T-L	1.34
	45/45-45	1.44
	L/T-L	1.26

Alcoa 2091 .144" Sheet

Aged 16/32 Hours at 335F

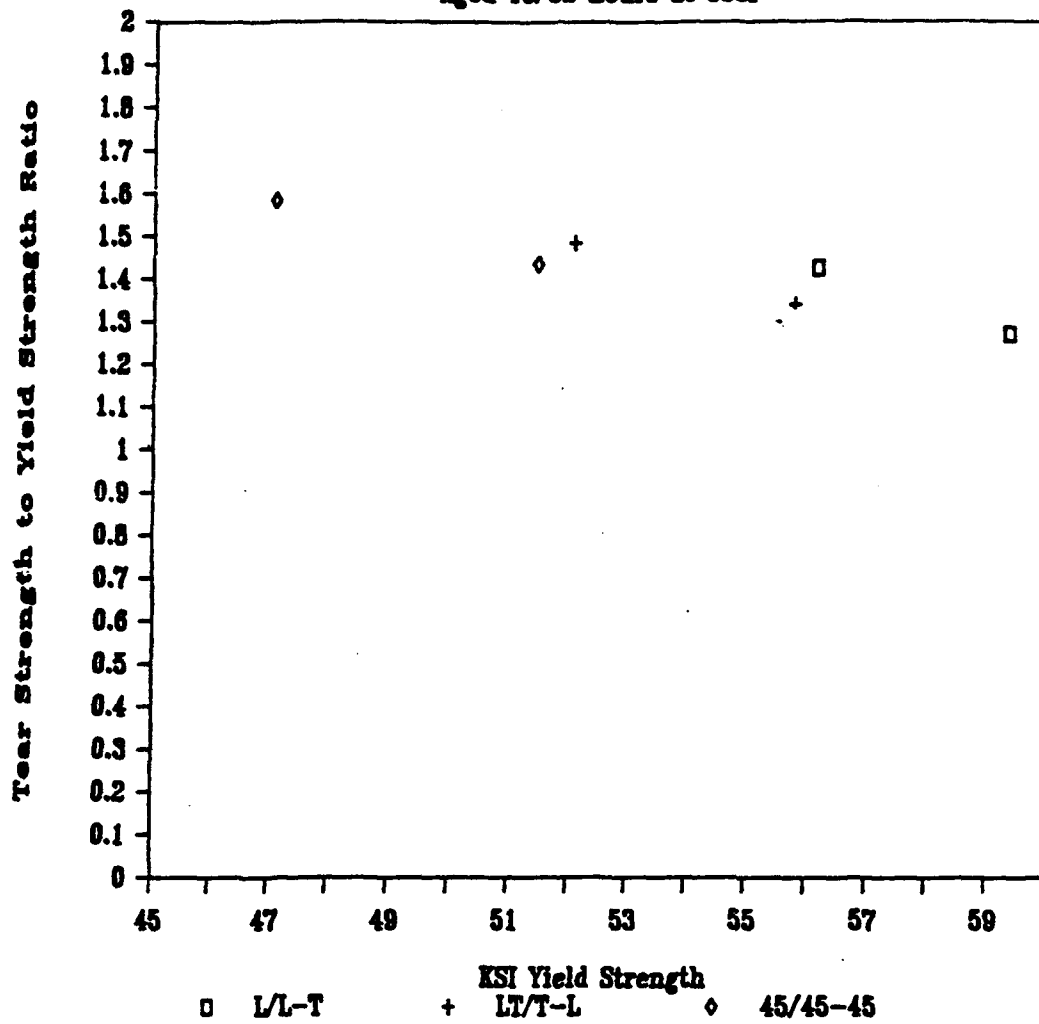


FIGURE K18. TEAR STRENGTH to YIELD STRENGTH RATIO VS YIELD STRENGTH DATA for 2091-T3 Aged 16/32 Hours at 335°F. General Dynamics.

TABLE K43

TENSILE RESULTS FOR ALCOA

2091-T8X SHEET (0.144" X 48" X 48")

COMPANY	TEST TEMP (DEGREES F)	ORIENT- ATION	ULTIMATE STRENGTH (KSI)	YIELD STRENGTH (KSI)	ELONG (%)	RA (%)	E (MSI)
NORTHROP	RT	LONG	63.4	53.5	15.6		10.8
			63.2	53.3	16.7		10.2
			63.7	53.7	14.7		10.5
			63.2	53.6	12.6		10.8
		AVERAGE	63.4	53.5	14.9		10.6
		STANDARD DEVIATION	0.2	0.2	1.7		0.3

TABLE K44

TENSILE RESULTS FOR ALCOA

2091-T8X SHEET (0.144" X 48" X 48")

COMPANY	TEST TEMP (DEGREES F)	ORIENT- ATION	ULTIMATE STRENGTH (KSI)	YIELD STRENGTH (KSI)	ELONG (%)	RA (%)	E (MSI)
NORTHROP	RT	45		44.3			10.4
			63.3	44.1	19.8		10.5
			62.4	43.5	17.8		11.8
			62.8	44.9	19.2		11.9
		AVERAGE	62.8	44.2	18.9		11.2
		STANDARD DEVIATION	0.5	0.6	1.0		0.8

TABLE K45

TENSILE RESULTS FOR ALCOA

2091-T8X SHEET (0.144" X 48" X 48")

COMPANY	TEST TEMP (DEGREES F)	ORIENT- ATION	ULTIMATE STRENGTH (KSI)	YIELD STRENGTH (KSI)	ELONG (%)	RA (%)	E (MSI)
NORTHROP	RT	L TRANS	67.5	48.7	12.1		10.6
			68.2	49.2	12.7		11.2
			67.8	48.8	13.1		11.3
		AVERAGE	67.8	48.9	12.6		11.0
		STANDARD DEVIATION	0.4	0.3	0.5		0.4

TABLE K46

COMPRESSION RESULTS FOR ALCOA

2091-T8X SHEET (0.144" X 48" X 48")

COMPANY	TEST TEMPERATURE (DEGREES F)	ORIENTATION	COMPRESSIVE YIELD STRENGTH (KSI)	COMPRESSIVE MODULUS (KSI)
NORTHROP	RT	LONG	42.7	12.0
			42.5	11.5
			42.9	11.7
		AVERAGE	42.7	11.7
		STANDARD DEVIATION	0.3	0.2

TABLE K47

COMPRESSION RESULTS FOR ALCOA

2091-T8X SHEET (0.144" X 48" X 48")

COMPANY	TEST TEMPERATURE (DEGREES F)	ORIENTATION	COMPRESSIVE YIELD STRENGTH (KSI)	COMPRESSIVE MODULUS (KSI)
NORTHROP	RT	L TRANS	51.5	11.5
			51.4	11.3
			51.3	11.3
		AVERAGE	51.4	11.4
		STANDARD DEVIATION	0.1	0.1

TABLE K48
SLOTTED SHEAR RESULTS FOR ALCOA
2091-T8X SHEET (0.144" X 48" X 48")

COMPANY	ORIENTATION	SHEAR STRENGTH (KSI)
NORTHROP	LONG	40.6
		40.5
		40.5
	AVERAGE	40.5
	STANDARD DEVIATION	0.1

TABLE K49
SLOTTED SHEAR RESULTS FOR ALCOA
2091-T8X SHEET (0.144" X 48" X 48")

COMPANY	ORIENTATION	SHEAR STRENGTH (KSI)
NORTHROP	L TRANS	43.0
		43.0
		43.2
	AVERAGE	43.1
	STANDARD DEVIATION	0.1

TABLE K50

BEARING RESULTS FOR ALCOA

2091-T8X SHEET (0.144" X 48" X 48")

COMPANY	ORIENTATION	e/D	BEARING		BEARING	
			ULT.	STR.	YIELD	STR.
			(KSI)		(KSI)	
NORTHROP	LONG	1.5	96.8		76.3	
			92.9		73.6	
			AVERAGE		75.0	
STANDARD DEVIATION			2.8		1.9	

TABLE K51

BEARING RESULTS FOR ALCOA

2091-T8X SHEET (0.063" X 48" X 48")

COMPANY	ORIENTATION	e/D	BEARING		BEARING	
			ULT.	STR.	YIELD	STR.
			(KSI)		(KSI)	
NORTHROP	L TRANS	1.5	100.8		76.1	
			99.3		75.1	
			97.0		74.0	
			AVERAGE		75.1	
STANDARD DEVIATION		1.9		1.1		

TABLE K52
 BEARING RESULTS FOR ALCOA
 2091-T8X SHEET (0.144" X 48" X 48")

COMPANY	ORIENTATION	e/D	BEARING		BEARING	
			ULT.	STR.	YIELD	STR.
			(KSI)		(KSI)	
NORTHROP	LONG	2.0		120.7		89.8
				122.4		89.1
				123.9		91.8
		AVERAGE		122.3		90.2
		STANDARD DEVIATION		1.6		1.4

TABLE K53
 BEARING RESULTS FOR ALCOA
 2091-T8X SHEET (0.144" X 48" X 48")

COMPANY	ORIENTATION	e/D	BEARING		BEARING	
			ULT.	STR.	YIELD	STR.
			(KSI)		(KSI)	
NORTHROP	L TRANS	2.0		125.6		91.9
				126.9		91.0
				126.1		94.6
		AVERAGE		126.2		92.5
		STANDARD DEVIATION		0.7		1.9

TABLE K54

R-CURVE FRACTURE TOUGHNESS RESULTS FOR
ALCOA 2091-T8X SHEET (0.144" X 48" X 48")

COMPANY	SPECIMEN I.D.	ORIENTATION	K _c (KSI SQRT-IN)
NORTHROP	T6RL1	L-T	135.0

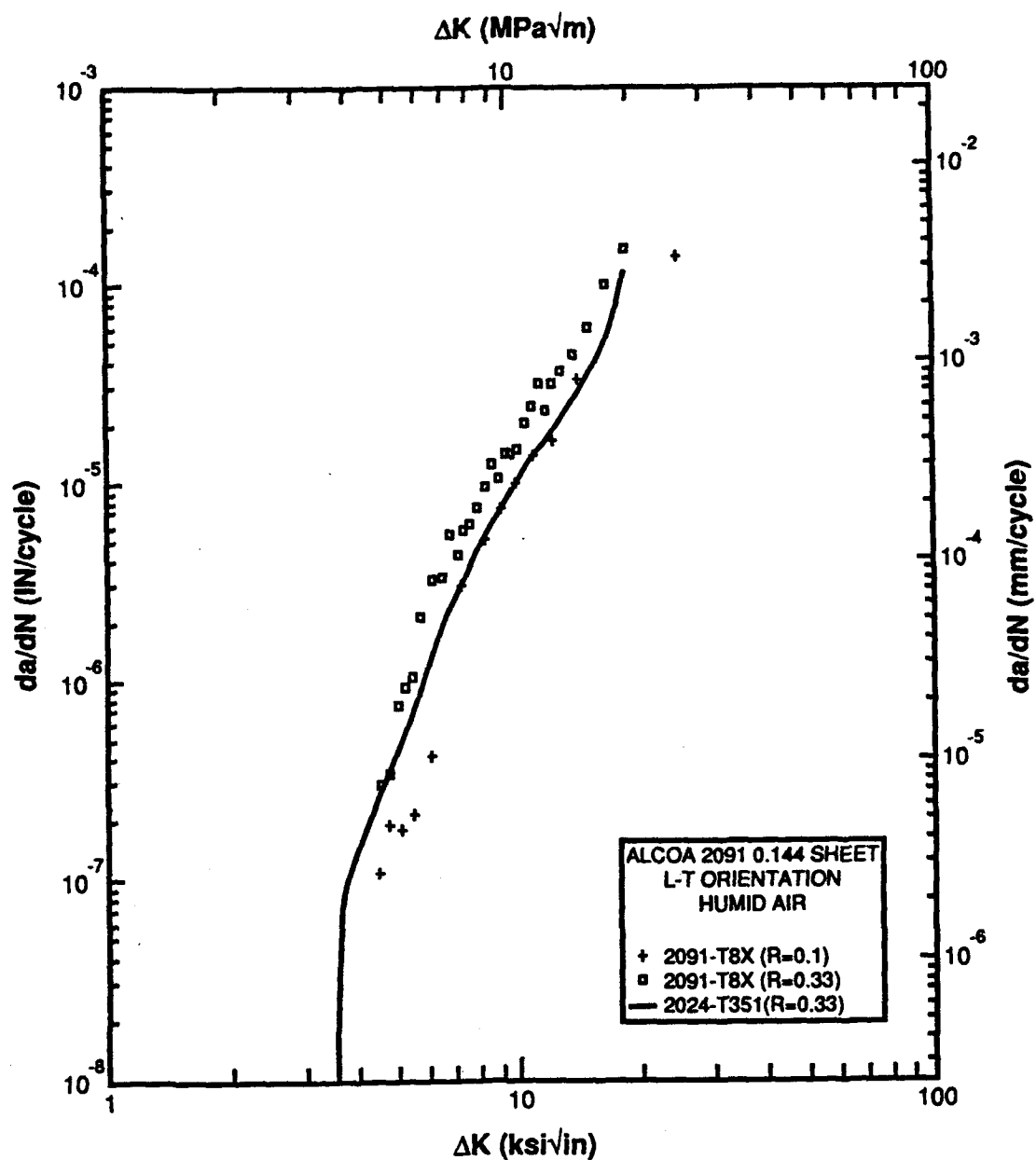


FIGURE K19. FATIGUE CRACK GROWTH RATES FOR 2091-T8X 0.144 INCH SHEET RELATIVE TO 2024-T351 (L-T ORIENTATION). NORTHROP.

TABLE K55
FATIGUE CRACK GROWTH RATE DATA ASSOCIATED
WITH FIGURE K19 (SPECIMEN T6 FL-1)

CRACK GROWTH TEST OF ALCOA 2091	SPEC T6FL-1
M(T) SPECIMEN TYPE	L-T ORIENTATION
TEMP = 80	REL HUM = 95 % 11-MAY-89
W = 2.9998 IN	B = .142 IN R = .1
FREQUENCY = 10 HZ	HUMID AIR ENVIRONMENT
GRID SPACING = .05 IN	FILE CODE: RK1:C00145.DDN
YIELD STRESS = 54 KSI	FITO CODE: RK1:C00145.DF0

SPECIMEN T6FL-1				M(T) SPECIMEN TYPE			
REF #	K-MAX	2A IN	2A/W	K-BAR	DELTA K-BAR	DA/DN IN/CYC	VALID PER ASTM
	4.9	.3041	.1014				
2	5.09	.3281	.1094	5	4.5	1.08794E-07	Y
3	5.48	.3781	.126	5.29	4.76	1.91278E-07	Y
4	5.88	.4326	.1442	5.68	5.11	1.81063E-07	Y
5	6.25	.4846	.1615	6.06	5.46	2.16216E-07	Y
6	7.22	.6331	.211	6.74	6.07	4.36765E-07	Y
7	8.81	.8901	.2967	8.02	7.22	3.21250E-06	Y
8	9.51	1.0046	.3349	9.16	8.25	5.45238E-06	Y
9	10.34	1.1361	.3787	9.92	8.93	7.73530E-06	Y
10	11.33	1.2871	.4291	10.83	9.75	1.04138E-05	Y
11	12.64	1.4711	.4904	11.97	10.77	1.47200E-05	Y
12	14.18	1.6631	.5544	13.39	12.05	1.74545E-05	Y
13	17.13	1.9566	.6522	15.58	14.02	3.49405E-05	Y
14	48.43	2.8206	.9403	27.14	24.43	1.45651E-04	Y

TABLE K56
FATIGUE CRACK GROWTH RATE DATA ASSOCIATED
WITH FIGURE K19 (SPECIMEN T6 FL-3)

CRACK GROWTH TEST OF ALCOA 2091 SHEET		SPEC T6FL-3
M(T) SPECIMEN TYPE	L-T ORIENTATION	
TEMP = 78	REL HUM = 95 %	28-JUN-89
W = 3 IN	B = .1411 IN	R = .33
FREQUENCY = 10 HZ	HUMID AIR ENVIRONMENT	
GRID SPACING = .05 IN	FILE CODE: RK1:D00045.DDN	
YIELD STRESS = 53.5 KSI	FITO CODE: RK1:D00045.DFO	

SPECIMEN T6FL-3				M(T) SPECIMEN TYPE			
REF #	K-MAX	2A IN	2A/W	K-BAR	DELTA K-BAR	DA/DN IN/CYC	VALID PER ASTM
1	6.59	.5301	.1767				
2	6.93	.5806	.1935	6.76	4.53	3.15625E-07	Y
3	7.2	.6231	.2077	7.07	4.73	3.54167E-07	Y
4	7.6	.6861	.2287	7.4	4.96	7.87500E-07	Y
5	7.91	.7351	.245	7.76	5.2	9.79999E-07	Y
6	8.18	.7791	.2597	8.05	5.39	1.10000E-06	Y
7	8.72	.8666	.2889	8.45	5.66	2.18750E-06	Y
8	9.35	.9681	.3227	9.03	6.05	3.38333E-06	Y
9	9.78	1.0374	.3458	9.56	6.41	3.46500E-06	Y
10	10.35	1.1276	.3759	10.06	6.74	5.63750E-06	Y
11	10.7	1.1816	.3939	10.52	7.05	4.50000E-06	Y
12	11.01	1.2286	.4095	10.85	7.27	5.87502E-06	Y
13	11.44	1.2931	.431	11.22	7.52	6.44999E-06	Y
14	11.98	1.3701	.4567	11.71	7.84	7.70000E-06	Y
15	12.55	1.4486	.4829	12.26	8.21	9.81249E-06	Y
16	13.13	1.5246	.5082	12.84	8.6	1.26667E-05	Y
17	13.47	1.5676	.5225	13.3	8.91	1.07500E-05	Y
				13.71	9.18	1.45000E-05	Y

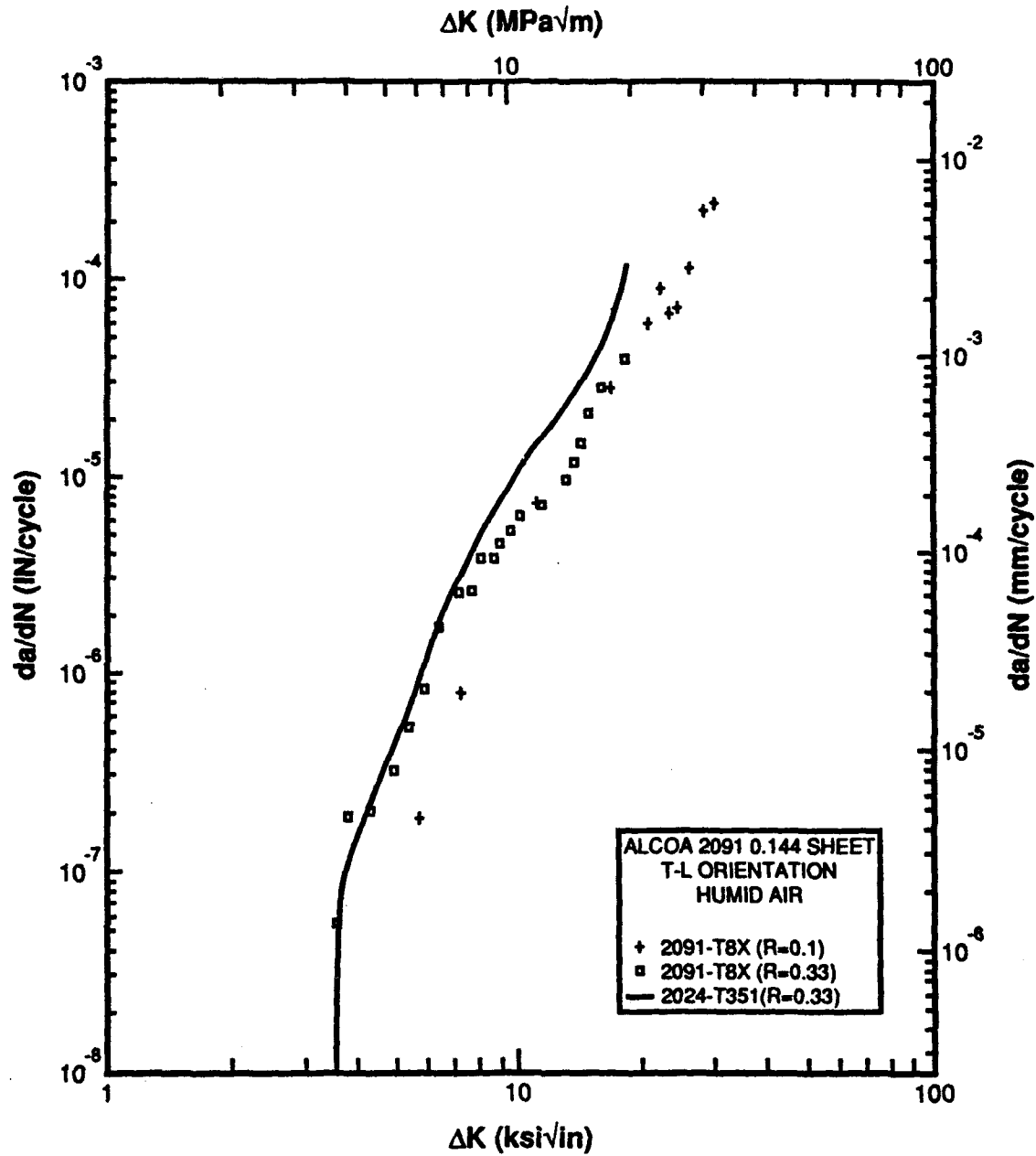


FIGURE K20. FATIGUE CRACK GROWTH RATES FOR 2091-T8X 0.144 INCH SHEET RELATIVE TO 2024-T351 (T-L ORIENTATION). NORTHROP.

TABLE K57
FATIGUE CRACK GROWTH RATE DATA ASSOCIATED
WITH FIGURE K20 (SPECIMEN T6 FL-1)

CRACK GROWTH TEST OF ALCOA 2091 SHEET SPEC T6FT-1
M(T) SPECIMEN TYPE T-L ORIENTATION
TEMP = 80 REL HUM = 95 % 12-JUL-89
W = 3 IN B = .1424 IN R = .1
FREQUENCY = 10 HZ HUMID AIR ENVIRONMENT
GRID SPACING = .05 IN FILE CODE: RK1:D00046.DDN
YIELD STRESS = 49 KSI FITO CODE: RK1:D00047.DFO

SPECIMEN T6FT-1				M(T) SPECIMEN TYPE			
REF	K-MAX	2A IN	2A/W	K-BAR	DELTA K-BAR	DA/DN IN/CYC	VALID PER ASTM
1	5.57	.1437	.0479				
2	6.92	.2212	.0737	6.27	5.64	1.93750E-07	Y
3	8.8	.3537	.1179	7.89	7.1	8.28125E-07	Y
4	15.35	.9592	.3197	12.19	10.97	7.56875E-06	Y
5	21.97	1.5467	.5156	18.52	16.66	2.93750E-05	Y
6	23.67	1.6702	.5567	22.81	20.53	6.17500E-05	Y
7	25.08	1.7632	.5877	24.36	21.93	9.30001E-05	Y
8	26.2	1.8317	.6106	25.63	23.07	6.84999E-05	Y
9	27.49	1.9052	.6351	26.84	24.15	7.35000E-05	Y
10	29.8	2.0222	.6741	28.62	25.76	1.17000E-04	Y
11	31.88	2.1137	.7046	30.82	27.74	2.28751E-04	Y
12	33.55	2.1792	.7264	32.7	29.43	2.51922E-04	Y

TABLE K58
FATIGUE CRACK GROWTH RATE DATA ASSOCIATED
WITH FIGURE K20 (SPECIMEN T6FT-3)

CRACK GROWTH TEST OF ALCOA 2091				SPEC T6FT-3			
M(T) SPECIMEN TYPE			T-L ORIENTATION				
TEMP = 80			REL HUM = 50 %		08-06-89		
W = 3.0002 IN			B = .1425 IN		R = .33		
FREQUENCY = 10 HZ			LAB AIR ENVIRONMENT				
GRID SPACING = .05 IN			FILE CODE: RK1:A00702.BDN				
YIELD STRESS = 54 KSI			FITO CODE: RK1:A00702.DFO				
SPECIMEN T6FT-3			M(T) SPECIMEN TYPE				
REF	K-MAX	2A IN	2A/W	K-BAR	DELTA K-BAR	DA/DN IN/CYC	VALID PER ASTM
1	5.31	.2652	.0884				
2	5.45	.279	.093	5.38	3.6	5.72917E-08	Y
3	5.9	.3257	.1086	5.68	3.8	1.93582E-07	Y
4	6.99	.4517	.1506	6.46	4.33	2.06557E-07	Y
5	7.58	.5247	.1749	7.29	4.88	3.29422E-07	Y
6	8.37	.6294	.2098	7.98	5.34	5.51316E-07	Y
7	8.98	.7127	.2376	8.67	5.81	8.59134E-07	Y
8	9.87	.8372	.279	9.42	6.31	1.77857E-06	Y
9	11.21	1.0257	.3419	10.54	7.06	2.69286E-06	Y
10	11.6	1.0797	.3599	11.41	7.64	2.70000E-06	Y
11	12.63	1.2172	.4057	12.11	8.11	3.98551E-06	Y
12	13.09	1.2772	.4257	12.86	8.61	4.05405E-06	Y
13	13.63	1.3452	.4484	13.36	8.95	4.72222E-06	Y
14	14.77	1.4802	.4934	14.19	9.51	5.44355E-06	Y
15	15.36	1.5457	.5152	15.06	10.09	6.55000E-06	Y
16	19.08	1.8932	.631	17.12	11.47	7.40938E-06	Y
17	19.96	1.9602	.6534	19.51	13.07	1.01515E-05	Y
18	20.48	1.9975	.6658	20.22	13.55	1.24167E-05	Y
19	21.64	2.0737	.6912	21.05	14.1	1.52499E-05	Y
20	22.71	2.1379	.7126	22.17	14.85	2.14167E-05	Y
21	24.38	2.2262	.742	23.53	15.76	2.94166E-05	Y
22	29.4	2.4272	.809	26.72	17.9	4.02000E-05	Y

APPENDIX L

2091-T8 0.5 Inch Plate

TABLE L1
TENSILE RESULTS FOR ALCOA
2091-T8 PLATE (0.5" X 48" X 48")

COMPANY	TEST TEMP (DEGREES F)	ORIENT- ATION	ULTIMATE STRENGTH (KSI)	YIELD STRENGTH (KSI)	ELONG (%)	RA (%)	E (MSI)
MARTIN	RT	LONG	74.8	62.1	11.0	11.4	
MARIETTA, LOUISIANA			74.2	61.4	11.0	10.8	
			75.2	62.3	10.0	11.4	
AIR FORCE	RT	LONG	76.2	64.0	8.9	16.2	
			75.6	63.4	9.4	17.0	
			75.3	62.8	8.6	15.1	
		AVERAGE	75.2	62.7	9.8	13.7	
		STANDARD DEVIATION	0.7	0.9	0.4	1.1	

TABLE L2
TENSILE RESULTS FOR ALCOA
2091-T8 PLATE (0.5" X 48" X 48")

COMPANY	TEST TEMP (DEGREES F)	ORIENT- ATION	ULTIMATE STRENGTH (KSI)	YIELD STRENGTH (KSI)	ELONG (%)	RA (%)	E (MSI)
AIR FORCE	RT	30	71.6	52.9	11.6	16.2	
			71.6	53.2	11.7	18.4	
		AVERAGE	71.6	53.1	11.7	17.3	
		STANDARD DEVIATION	0.0	0.2	0.1	1.5	

TABLE L3

TENSILE RESULTS FOR ALCOA

2091-T8 PLATE (0.5" X 48" X 48")

COMPANY	TEST TEMP (DEGREES F)	ORIENT- ATION	ULTIMATE STRENGTH (KSI)	YIELD STRENGTH (KSI)	ELONG (%)	RA (%)	E (MSI)
AIR FORCE	RT	45	64.0	46.6	19.4	32.9	
			63.6	45.9	19.1	35.5	
			63.6	45.9	19.6	33.6	
		AVERAGE	63.7	46.1	19.4	34.0	
		STANDARD DEVIATION	0.2	0.4	0.3	1.3	

TABLE L4

TENSILE RESULTS FOR ALCOA

2091-T8 PLATE (0.5" X 48" X 48")

COMPANY	TEST TEMP (DEGREES F)	ORIENT- ATION	ULTIMATE STRENGTH (KSI)	YIELD STRENGTH (KSI)	ELONG (%)	RA (%)	E (MSI)
MARTIN MARIETTA, LOUISIANA	RT	L TRANS	72.9	55.0	14.0	18.8	
			72.2	54.1	14.0	18.8	
			73.5	55.0	14.0	14.2	
AIR FORCE	RT	L TRANS	73.6	55.6	12.1	24.9	
			73.8	55.7	11.5	24.5	
			73.8	55.4	13.0	22.7	
		AVERAGE	73.3	55.1	13.1	20.7	
		STANDARD DEVIATION	0.6	0.6	1.1	4.1	

TABLE L5
COMPRESSION RESULTS FOR ALCCA
2091-T8 PLATE (0.5" X 48" X 48")

COMPANY	TEST TEMPERATURE (DEGREES F)	ORIENTATION	COMPRESSIVE YIELD STRENGTH (KSI)	COMPRESSIVE MODULUS (MSI)
MARTIN MARIETTA, LOUISIANA	RT	LONG	52.2	11.8
			51.4	11.8
			52.4	11.8
			AVERAGE	
	STANDARD DEVIATION		0.5	0.0

TABLE L6
COMPRESSION RESULTS FOR ALCOA
2091-T8 PLATE (0.5" X 48" X 48")

COMPANY	TEST TEMPERATURE (DEGREES F)	ORIENTATION	COMPRESSIVE YIELD STRENGTH (KSI)	COMPRESSIVE MODULUS (KSI)
MARTIN MARIETTA, LOUISIANA	RT	L TRANS	57.9	11.9
			58.8	11.9
		AVERAGE	58.4	11.9
		STANDARD DEVIATION	0.6	0.0

TABLE L7

FRACTURE TOUGHNESS RESULTS FOR ALCOA

2091-T8 PLATE (0.5" X 48" X 48")

COMPANY	ORIENTATION	KIC (KSI in ^{0.5})	Kq (KSI in ^{0.5})	COMMENT
MARTIN	L - T		33.8	INVALID(1)
MARIETTA,			31.1	INVALID(1)
LOUISIANA			37.4	INVALID(1)
	AVERAGE		34.1	
	STANDARD DEVIATION		3.2	

(1): SPECIMEN SIZE TOO SMALL

TABLE L8

FRACTURE TOUGHNESS RESULTS FOR ALCOA

2091-T8 PLATE (0.5" X 48" X 48")

COMPANY	ORIENTATION	KIC (KSI in ^{0.5})	Kq (KSI in ^{0.5})	COMMENT
MARTIN	T - L		34.0	INVALID(1)
MARIETTA,			37.8	INVALID(1)
LOUISIANA			37.4	INVALID(1)
	AVERAGE		36.4	
	STANDARD DEVIATION		2.1	

(1): SPECIMEN SIZE TOO SMALL

TABLE L9
POST-OVERLOAD FATIGUE TEST RESULTS for 2091-T8
0.5 INCH PLATE and 2091-T83 0.144 INCH PLATE

R=0.05 LAB AIR $\Delta K=6.0 \text{ ksi}(\text{in})^{1/2}$ ONE OVERLOAD CYCLE APPLIED

<u>% O.L.</u>	<u>a/W</u>	<u>Pcl/Pmax</u>	<u>da/dN @ O.L.</u> <u>(u-in/cyc)</u>	<u>DELAY CYCLES</u> <u>(x10⁻³)</u>
PLATE SPECIMEN THICKNESS • 0.250"				
80	0.369	0.402	0.184	171.7
80	0.463	0.456	0.199	146.7
80	0.559	0.449	0.414	83.4
80	0.600	0.386	0.399	85.8
PLATE SPECIMEN THICKNESS • 0.140"				
80	0.401	0.645	0.097	arrest
80	0.447	0.603	0.095	arrest
60	0.407	0.535	0.135	137.6
60	0.415	0.640	0.076	arrest
60	0.484	0.584	0.057	891.0
60	0.502	0.647	0.149	126.7
60	0.541	0.600	0.140	72.8
60	0.654	0.523	0.120	59.0
60	0.696	0.574	0.107	71.5
SHEET SPECIMEN THICKNESS • 0.140"				
60	0.284	0.516	1.227	13.2
60	0.276	0.511	0.696	31.6
60	0.314	0.505	2.435	17.4
60	0.315	0.501	1.381	19.7
60	0.349	0.483	1.133	30.3
60	0.368	0.45	2.495	13.8
60	0.400	0.413	2.331	22.0
60	0.447	0.446	1.624	14.3
60	0.516	0.379	3.143	11.6
60	0.574	0.344	3.527	10.3

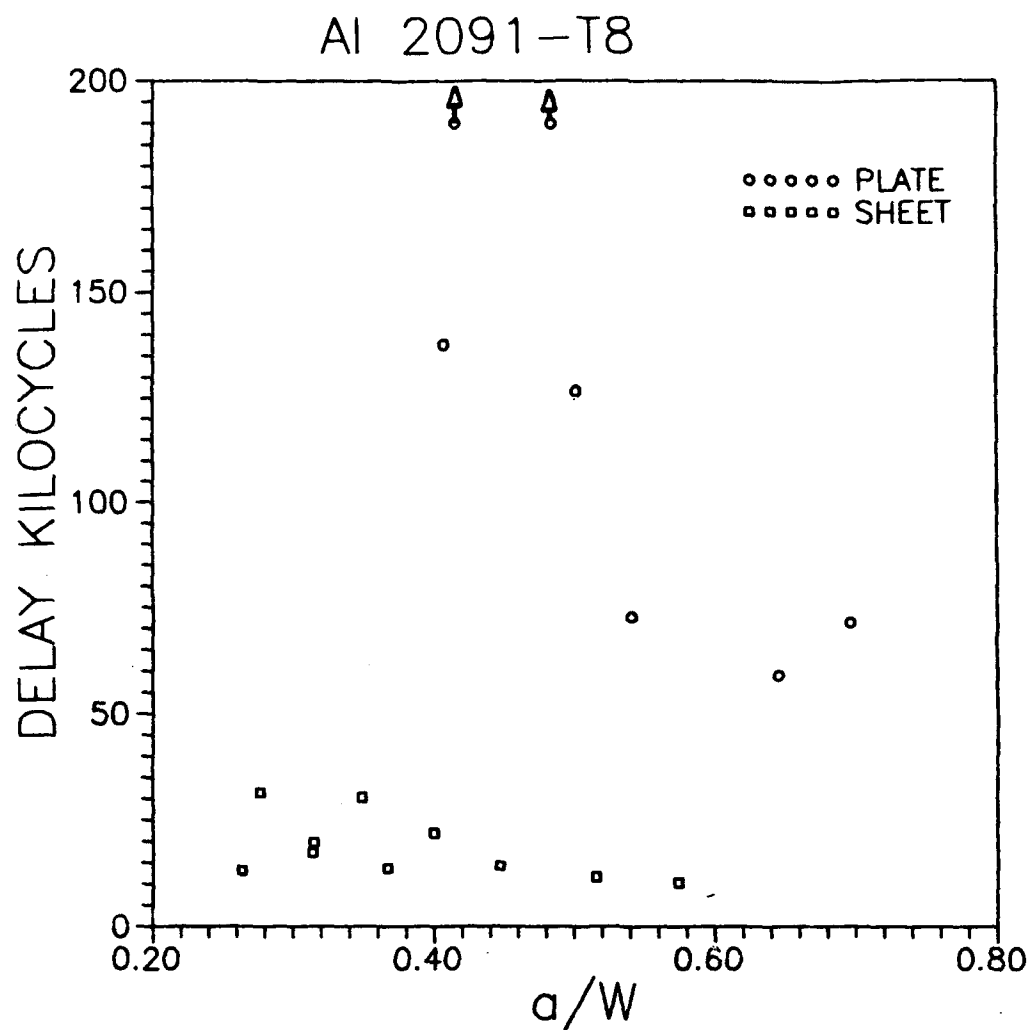


FIGURE L1. A Comparison of Delay Cycles Due to Fatigue Crack Growth Retardation for a 60 Percent Overload Cycle at a stress Intensity of 6 KSI $\sqrt{\text{in}}$ in 2091-T81 Plate Versus 2091-T83 Sheet. Thickness of the Compact Tension Specimens Used for Plate and Sheet was 0.144 Inch.

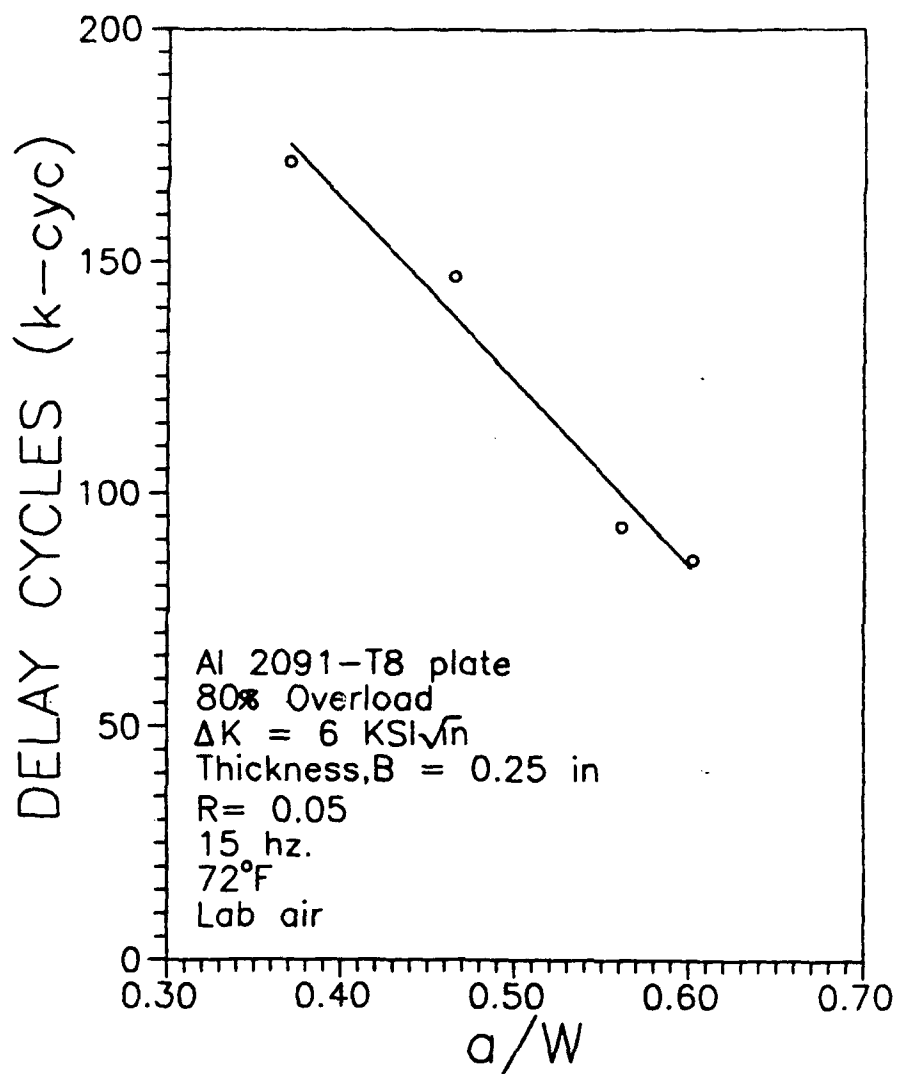


FIGURE L2. Delay Cycles Due to Fatigue Crack Growth Retardation for an 80 Percent Overload Cycle at a Stress Intensity Range of $6 \text{ KSI}\sqrt{\text{in}}$, in 2091-T81 Plate, with a Specimen Thickness of 0.250 Inch.

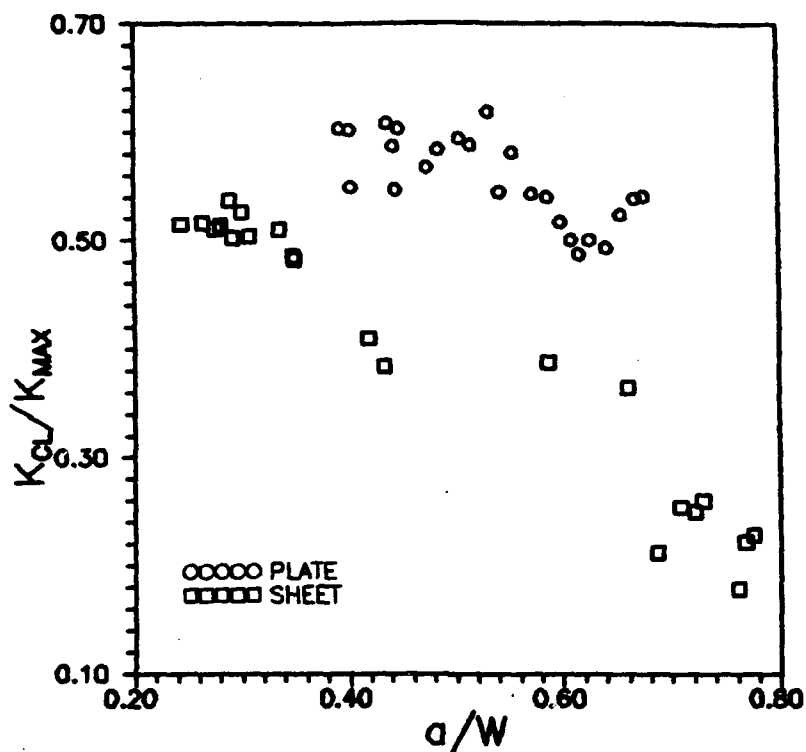


FIGURE L3. A Comparison of the Crack Closure Level Prior to the Application of a 60 Percent Overload Cycle. Note the Larger Level of Crack Closure in the Plate as Compared to Sheet Which Correlates with the Overload Delay Cycles.

TABLE L10
POST-OVERLOAD RECOVERY EXTENSION
IN 2091 PLATE AND SHEET

delta-K= 6.0 ksi(in) ^{.5} 15 hz. Lab Air		R=.05	One Overload Cycle Applied Crack Tip Plastic Zone=0.004 (in)	
<u>a/W</u>	<u>da/dN @ O.L. (in/cyc)</u>	<u>Accelerate into Plastic Zone?</u>	<u>Post O.L. Recovery delta-A (in)</u>	
PLATE (.250 in. thick) 80 PERCENT OVERLOAD				
0.369	0.184	Yes	0.020	
0.463	0.199	Yes	0.025	
0.559	0.414	Yes	0.025	
0.600	0.399	Yes	0.015	
PLATE (.144 in. thick) 80 PERCENT OVERLOAD				
0.401	0.097	Yes	arrest	
0.447	0.095	No	arrest	
PLATE (.144 in. thick) 60 PERCENT OVERLOAD				
0.407	0.135	No	0.015	
0.415	0.078	No	arrest	
0.484	0.057	No	0.024	
0.502	0.149	No	0.016	
0.541	0.140	No	0.015	
0.654	0.120	No	0.009	
0.696	0.107	Yes	0.016	
SHEET (.144 in. thick) 60 PERCENT OVERLOAD				
0.246	1.227	Yes	0.016	
0.276	0.696	Yes	0.015	
0.314	2.435	Yes	0.042	
0.315	1.381	Yes	0.020	
0.349	1.133	No	0.020	
0.368	2.495	Yes	0.026	
0.400	3.331	Yes	0.025	
0.447	1.624	Yes	0.016	
0.516	3.143	No	0.020	
0.574	3.527	Yes	0.026	

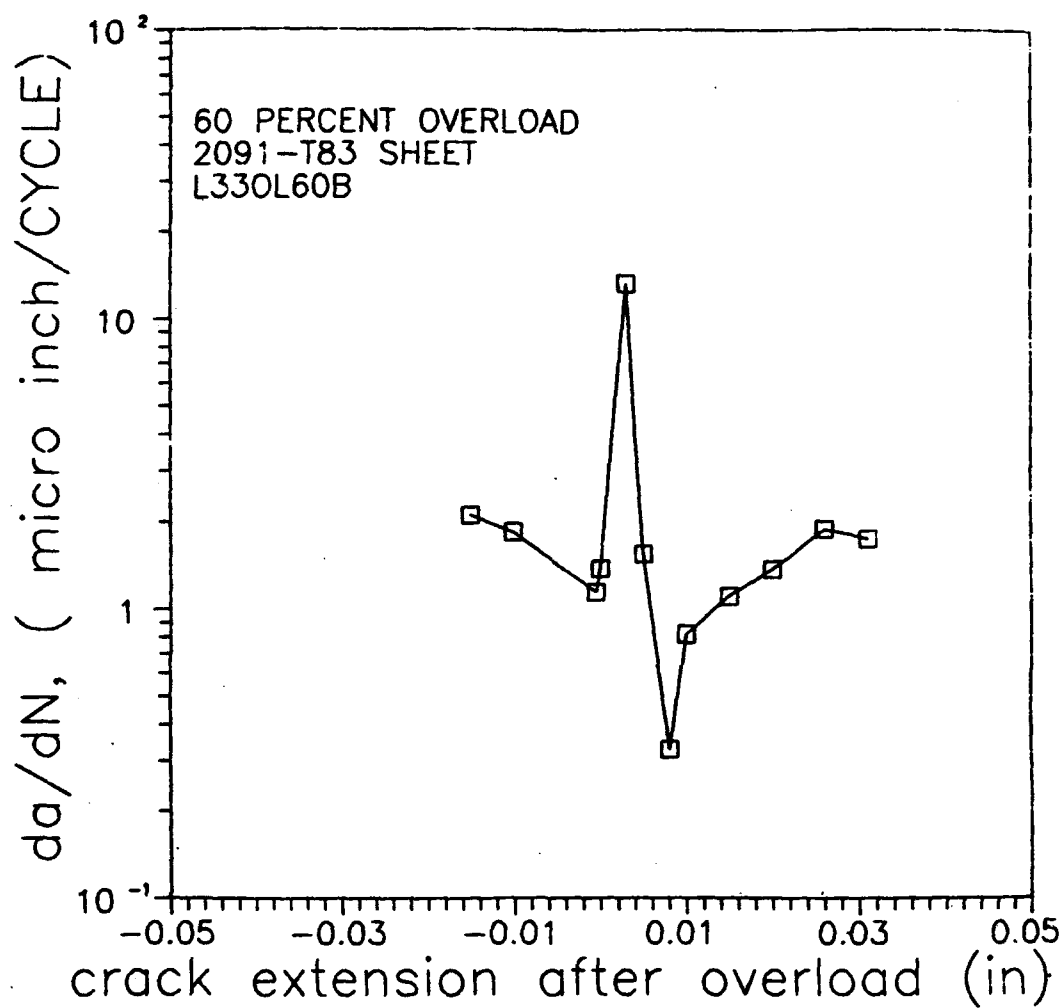


FIGURE L4. Crack Velocity Versus Post-Overload Crack Extension for Alloy 2091-T83 Sheet.

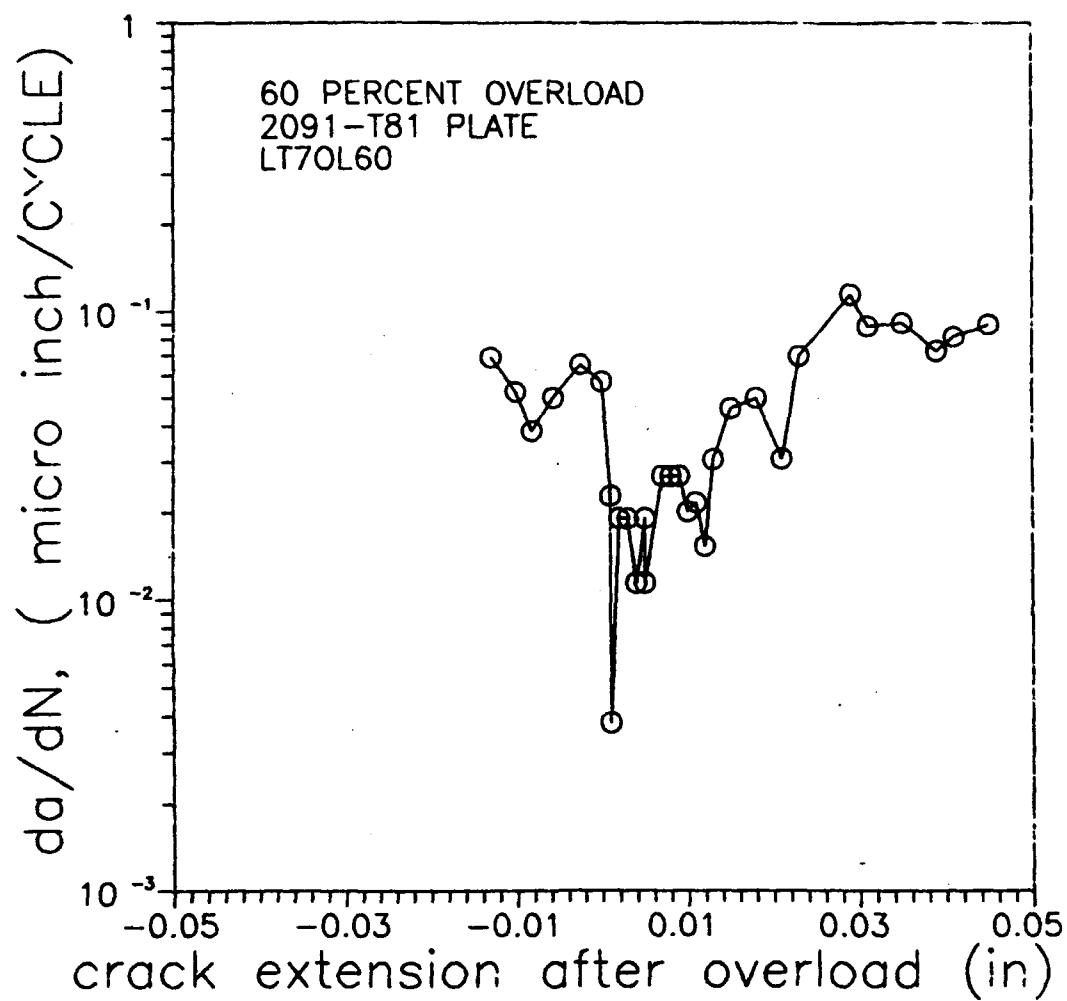


FIGURE L5. Crack Velocity Versus Post-Overload Crack Extension for Alloy 2091-T81 Plate 0.144 Inch Thick Specimen.

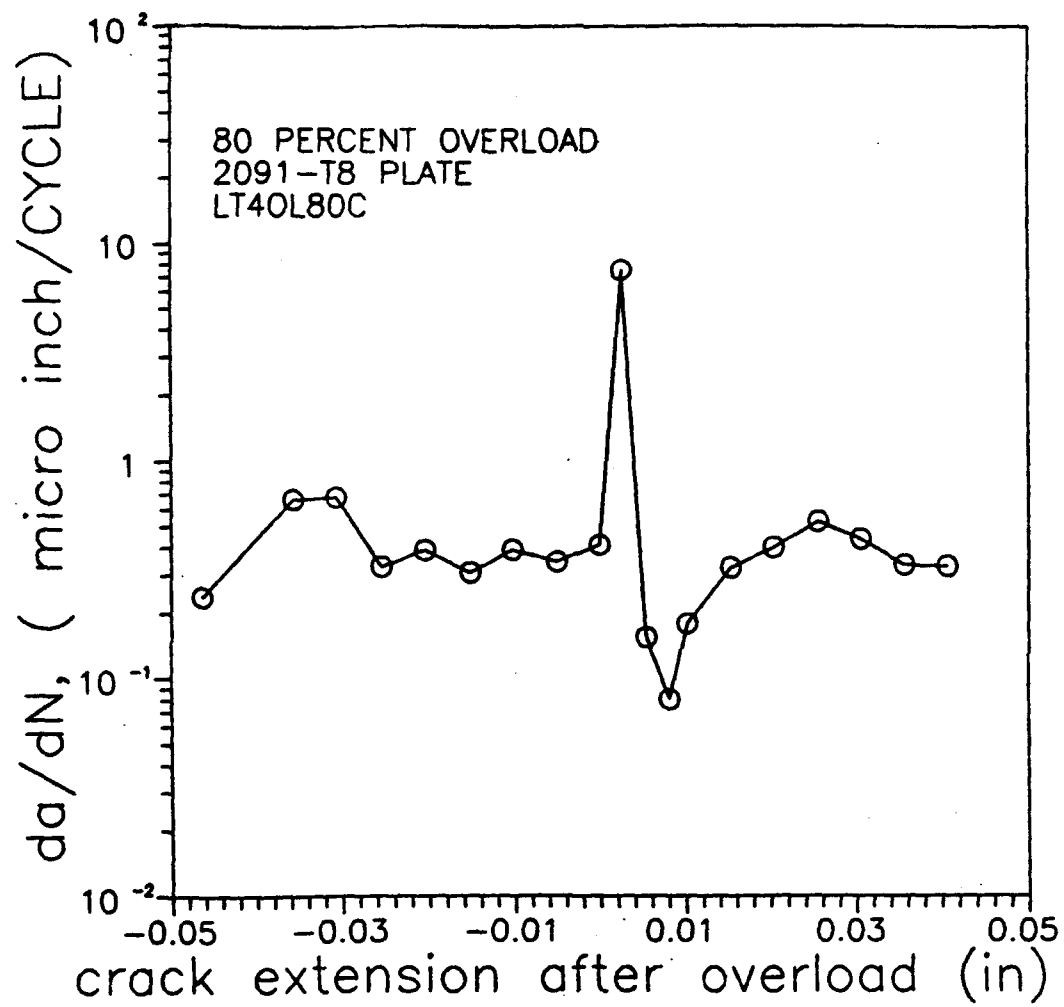
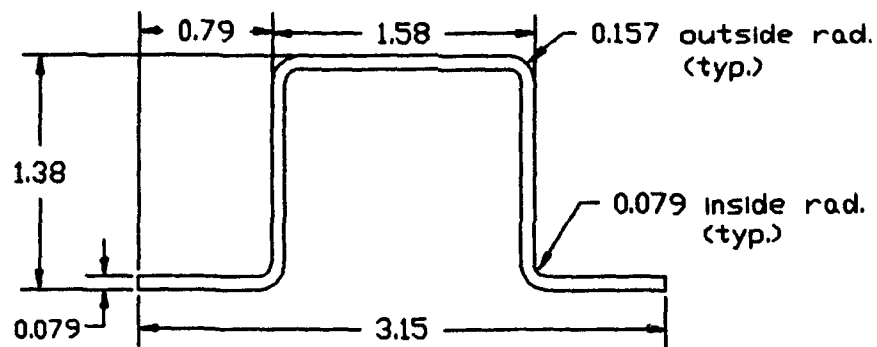


FIGURE L6. Crack Velocity Versus Post-Overload Crack Extension for Alloy 2091-T81 Plate 0.250 Inch Thick Specimen.

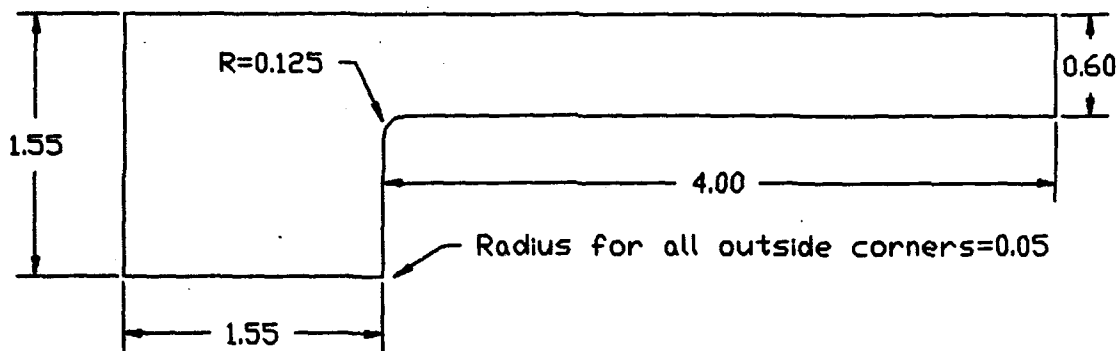
APPENDIX M

8090-T8 Hat Extrusion and 8090-T8771 L-Extrusion



ALL DIMENSIONS ARE IN INCHES

FIGURE M1. 8090-T8 HAT EXTRUSION GEOMETRY.



ALL DIMENSIONS ARE IN INCHES

FIGURE M2. 8090-T8 L-EXTRUSION GEOMETRY.

TABLE M1
TENSILE RESULTS AT t/2 LOCATION FOR
ALCOA 8090-T8 HAT EXTRUSION

COMPANY	TEST TEMP (DEGREES F)	ORIENT- ATION	ULTIMATE STRENGTH (KSI)	YIELD STRENGTH (KSI)	ELONG (%)	RA (%)	COMMENT
ARMY-MTL	RT	LONG	62.5	55.4	4.1	3.9	TOP
			62.8	56.0	5.5	5.7	TOP
			63.3	55.6	5.1	5.5	TOP
			63.5	56.7	4.3	5.9	TOP
			62.8	55.9	4.7	5.3	TOP
			62.9	56.3	3.8	4.5	TOP
		AVERAGE	62.9	56.0	4.6	5.1	
		STANDARD DEVIATION	0.4	0.4	0.6	0.8	

TABLE M2
TENSILE RESULTS AT t/2 LOCATION FOR
ALCOA 8090-T8 HAT EXTRUSION

COMPANY	TEST TEMP (DEGREES F)	ORIENT- ATION	ULTIMATE STRENGTH (KSI)	YIELD STRENGTH (KSI)	ELONG (%)	RA (%)	COMMENT
ARMY-MTL	RT	LONG	64.1	56.6	4.5	4.1	BOTTOM
			63.4	57.1	3.3	3.6	BOTTOM
			64.3	54.7	5.0	5.3	BOTTOM
			63.5	56.3	5.7	5.9	BOTTOM
			63.1	55.9	3.5	4.2	BOTTOM
			61.9	55.4	4.2	6.5	BOTTOM
		AVERAGE	63.4	56.0	4.4	4.9	
		STANDARD DEVIATION	0.9	0.9	0.9	1.1	

TABLE M3
TENSILE RESULTS AT t/2 LOCATION FOR
ALCOA 8090-T8 HAT EXTRUSION

COMPANY	TEST TEMP (DEGREES F)	ORIENT- ATION	ULTIMATE STRENGTH (KSI)	YIELD STRENGTH (KSI)	ELONG (%)	RA (%)	COMMENT
ARMY-MTL	RT	LONG	64.0	55.7	5.6	5.8	SIDE
			64.3	56.9	4.1	4.2	SIDE
			64.1	57.0	4.8	5.7	SIDE
			64.7	57.4	4.5	4.1	SIDE
			65.2	57.8	5.5	3.7	SIDE
			64.5	57.3	5.5	4.6	SIDE
		AVERAGE	64.5	57.0	5.0	4.7	
		STANDARD DEVIATION	0.4	0.7	0.6	0.9	

TABLE M4
BEARING RESULTS FOR ALCOA
8090-T8 HAT EXTRUSION

COMPANY	ORIENTATION	e/D	BEARING		BEARING COMMENT	
			ULT.	STR.	YIELD	STR.
			(KSI)		(KSI)	
ARMY-MTL	LONG	1.5		85.9	74.2	TOP
				87.5	73.4	TOP
				85.6	75.2	TOP
AVERAGE				86.3	74.3	
STANDARD DEVIATION				1.0	0.9	

TABLE M5
BEARING RESULTS FOR ALCOA
8090-T8 HAT EXTRUSION

COMPANY	ORIENTATION	e/D	BEARING		BEARING COMMENT	
			ULT.	STR.	YIELD	STR.
			(KSI)		(KSI)	
ARMY-MTL	LONG	1.5		91.7	81.6	SIDE
				95.4	80.9	SIDE
				93.2	80.1	SIDE
			AVERAGE		93.4	80.9
			STANDARD DEVIATION		1.9	0.7

TABLE M6
BEARING RESULTS FOR ALCOA
8090-T8 HAT EXTRUSION

COMPANY	ORIENTATION	e/D	BEARING ULT. STR. (KSI)	BEARING YIELD STR. (KSI)	COMMENT
ARMY-MTL	LONG	2.0	98.9	78.6	TOP
			104.0	82.5	TOP
			106.2	81.5	TOP
		AVERAGE	103.0	80.9	
		STANDARD DEVIATION	3.7	2.0	

TABLE M7
BEARING RESULTS FOR ALCOA
8090-T8 HAT EXTRUSION

COMPANY	ORIENTATION	e/D	BEARING ULT. STR. (KSI)	BEARING YIELD STR. (KSI)	COMMENT
ARMY-MTL	LONG	2.0	116.3	89.0	SIDE
			111.6	89.0	SIDE
			112.9	89.9	SIDE
		AVERAGE	113.6	89.3	
		STANDARD DEVIATION	2.4	0.5	

TABLE M8

TENSILE RESULTS AT t/2 LOCATION FOR
ALCOA 8090-T8771 "L" EXTRUSION

COMPANY	TEST TEMP (DEGREES F)	ORIENT- ATION	ULTIMATE STRENGTH (KSI)	YIELD STRENGTH (KSI)	ELONG (%)	RA (%)	E (MSI)
ARMY-MTL	RT	LONG	76.0	69.6	2.8		10.9
			68.8	57.5	3.2		11.0
			70.8	58.0	4.7		11.3
			69.8	58.0	5.2		11.1
			69.4	59.0	3.4		10.8
			69.4	58.0	4.1		11.3
MARTIN MARIETTA, LA	RT	LONG	72.1	64.9	5.0	4.9	(1)
			70.3	60.1	6.0	6.3	(1)
			70.4	59.6	5.0	3.3	(1)
			79.5	76.8	5.0	4.1	(2)
			79.5	76.3	3.0	3.9	(2)
			78.9	76.8	5.0	4.1	(2)
		AVERAGE	73.0	64.8	4.6	4.4	11.1
		STANDARD DEVIATION	4.4	8.4	0.9	1.0	0.2

(1): THICK SECTION

(2): THIN SECTION

TABLE M9

TENSILE RESULTS AT t/2 LOCATION FOR
ALCOA 8090-T8771 "L" EXTRUSION

COMPANY	TEST TEMP (DEGREES F)	ORIENT- ATION	ULTIMATE STRENGTH (KSI)	YIELD STRENGTH (KSI)	ELONG (%)	RA (%)	E (MSI)
ARMY-MTL	RT	L TRANS	68.2	52.8	6.3		11.0
			68.4	53.8	5.0		10.8
			68.6	53.0	6.5		10.6
			68.0	52.5	6.5		10.3
			67.5	54.0	4.1		11.0
			68.5	53.5	5.9		10.8
MARTIN MARIETTA, LA	RT	L TRANS	69.9	55.1	8.0	11.0	(1)
			69.6	55.4	7.0	8.0	(1)
			70.0	55.2	8.5	9.0	(1)
		AVERAGE	68.7	53.9	6.4	9.3	10.8
		STANDARD DEVIATION	0.9	1.1	1.4	1.5	0.3

(1): THIN SECTION

TABLE M10

TENSILE RESULTS AT t/2 LOCATION FOR
ALCOA 8090-T8771 "L" EXTRUSION

COMPANY	TEST TEMP (DEGREES F)	ORIENT- ATION	ULTIMATE STRENGTH (KSI)	YIELD STRENGTH (KSI)	ELONG (%)	RA (%)	E (MSI)
ARMY-MTL	RT	S TRANS	66.5	51.0	6.0		9.9
			58.3	43.0	8.0		9.6
			67.0	52.0	8.0		9.8
		AVERAGE	63.9	48.7	7.3		9.8
		STANDARD DEVIATION	4.9	4.9	1.2		0.2

TABLE M11

COMPRESSION RESULTS AT t/2 LOCATION FOR
ALCOA 8090-T8771 "L" EXTRUSION

COMPANY	TEST TEMPERATURE (DEGREES F)	ORIENTATION	COMPRESSIVE YIELD STRENGTH (KSI)	COMPRESSIVE MODULUS (KSI)

ARMY-MTL	RT	LONG	65.3	10.6
			54.6	10.4
			53.8	11.1
			61.7	9.9
			52.8	11.9
			53.9	10.8
MARTIN MARIETTA, LA	RT	LONG	49.8	11.5 (1)
			43.4	(1)
			50.0	11.9 (1)
			54.1	11.9 (2)
			47.9	11.8 (2)
			47.7	11.8 (2)
AVERAGE			52.9	11.2
STANDARD DEVIATION			6.0	0.7

(1): THICK SECTION
(2): THIN SECTION

TABLE M12

COMPRESSION RESULTS AT $t/2$ LOCATION FOR
ALCOA 8090-T8771 "L" EXTRUSION

COMPANY	TEST TEMPERATURE (DEGREES F)	ORIENTATION	COMPRESSIVE YIELD STRENGTH (KSI)	COMPRESSIVE MODULUS (KSI)
ARMY-MTL	RT	L TRANS	58.2	9.5
			59.9	11.9
			58.8	13.4
			55.7	11.8
			58.1	11.3
			64.7	8.9
MARTIN MARIETTA, LA	RT	L TRANS	52.0	11.9 (1)
			49.8	11.7 (1)
			49.8	11.8 (1)
AVERAGE			56.3	11.4
STANDARD DEVIATION			5.0	1.4

(1): THICK SECTION

TABLE M13

COMPRESSION RESULTS AT $t/2$ LOCATION FOR
ALCOA 8090-T8771 "L" EXTRUSION

COMPANY	TEST TEMPERATURE (DEGREES F)	ORIENTATION	COMPRESSIVE YIELD STRENGTH (KSI)	COMPRESSIVE MODULUS (KSI)
ARMY-MTL	RT	S TRANS	51.5	10.1
			52.0	11.2
			52.0	11.5
MARTIN MARIETTA, LA	RT	S TRANS	50.1	11.7 (1)
			50.2	11.8 (1)
			50.1	11.4 (1)
AVERAGE			51.0	11.3
STANDARD DEVIATION			0.9	0.6

(1): THICK SECTION

TABLE M14
RIVET SHEAR RESULTS FOR ALCOA
8090-T8771 "L" EXTRUSION

COMPANY	ORIENTATION	SHEAR STRENGTH (KSI)
ARMY-MTL	LONG	40.7
		41.4
		45.0
		39.6
		41.4
		39.9
	AVERAGE	41.3
	STANDARD DEVIATION	2.3

TABLE M15
RIVET SHEAR RESULTS FOR ALCOA
8090-T8771 "L" EXTRUSION

COMPANY	ORIENTATION	SHEAR STRENGTH (KSI)
ARMY-MTL	L TRANS	38.3
		37.5
		35.5
		38.7
		38.0
		36.8
	AVERAGE	37.5
	STANDARD DEVIATION	1.4

TABLE M16

**FRACTURE TOUGHNESS RESULTS FOR
ALCOA 8090-T8771 "L" EXTRUSION**

COMPANY	ORIENTATION	KIC	K _q	COMMENT
		(KSI in ^{-0.5})	(KSI in ^{-0.5})	
ARMY-MTL	L-T		31.9	(1)
			32.9	(1)
			30.2	(1)
			29.0	(1)
MARTIN MARIETTA, LA	L-T		33.1	(1)
			38.5	(1)
		36.3		
	AVERAGE	36.3	32.6	
	STANDARD DEVIATION		3.3	

(1): INVALID DUE TO $B < 2.5(KQ/Fty)^2$

TABLE M17

FRACTURE TOUGHNESS RESULTS FOR
ALCOA 8090-T8771 "L" EXTRUSION

COMPANY	ORIENTATION	KIC (KSI in ^{0.5})	Kq (KSI in ^{0.5})	COMMENT
ARMY-MTL	T-L		29.8	(1), (2)
			28.9	(1), (2)
			30.8	(1), (2)
			30.2	(1), (2)
			30.9	(1), (2)
MARTIN MARIETTA, LA	T-L	20.2		
		19.7		
		18.0		
	AVERAGE	19.3	30.1	
	STANDARD DEVIATION	1.2	0.8	

(1): INVALID DUE TO $P_{max}/P_q > 1.10$ (2): INVALID DUE TO $B < 2.5(KQ/Fty)^2$

TABLE M18

FRACTURE TOUGHNESS RESULTS FOR
ALCOA 8090-T8771 "L" EXTRUSION

COMPANY	ORIENTATION	KIC (KSI in ^{0.5})	Kq (KSI in ^{0.5})	COMMENT
ARMY-MTL	S-L	22.6		
		22.6		
		22.7		
		22.4		
		22.3		
		21.5		
	AVERAGE	22.4		
	STANDARD DEVIATION	0.4		

TABLE M19

FRACTURE TOUGHNESS RESULTS FOR
ALCOA 8090-T8771 "L" EXTRUSION

COMPANY	ORIENTATION	KIC (KSI in ^{0.5})	Kq (KSI in ^{0.5})	COMMENT
MARTIN	S-T		19.2	(1)
MARIETTA, LA			21.7	(1)
		20.9		
	AVERAGE	20.9	20.5	
	STANDARD DEVIATION		1.8	

(1): INVALID DUE TO $P_{max}/P_q > 1.10$

TABLE M20

FATIGUE RESULTS WITH R=0.1 AND Kt=1.0 FOR
ALCOA 8090-T8771 "L" EXTRUSION

COMPANY	ORIENTATION	STRESS (KSI)	CYCLES
ARMY-MTL	LONG	47.5	30,000
		39.3	164,000
		30.1	1,411,000
		28.0	3,639,000
		27.8	171,000
		27.5	11,787,000 *
		26.2	10,382,000 *

(*): RUN OUT

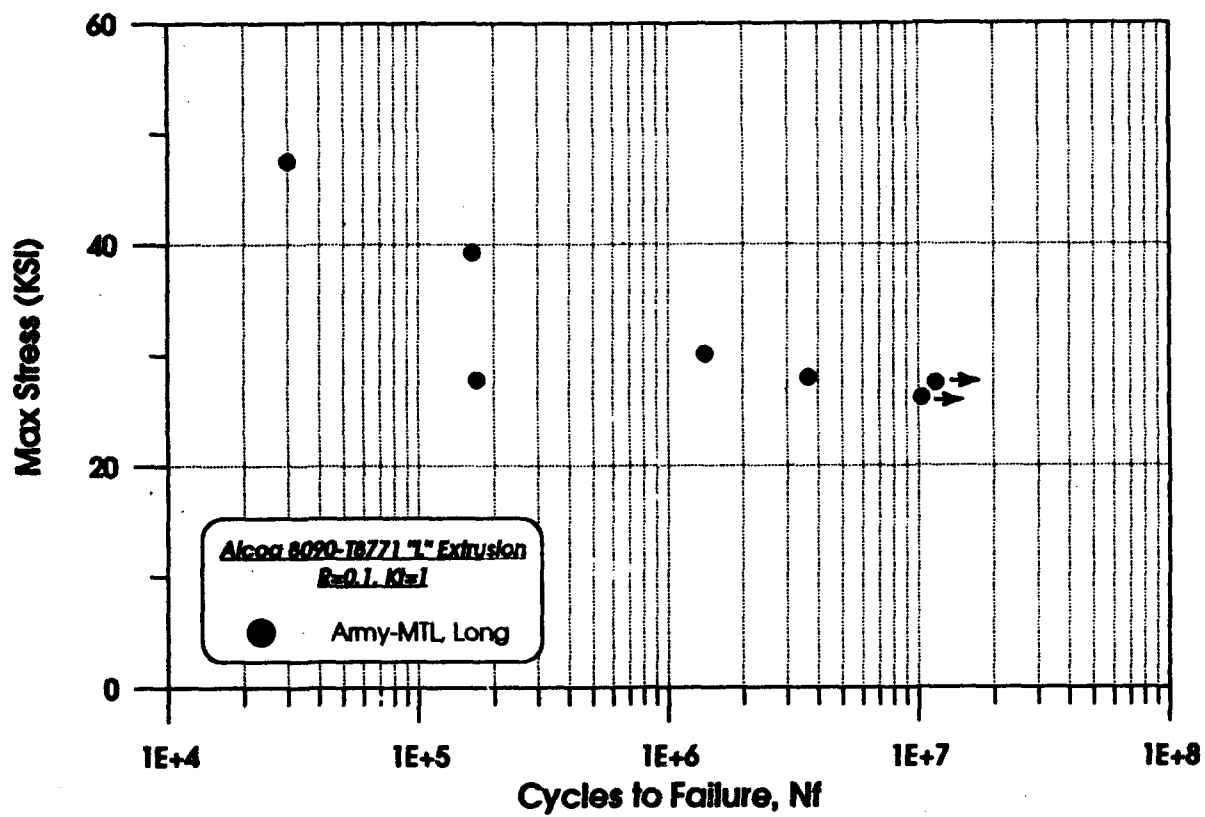


FIGURE M3. FATIGUE RESULTS FOR 8090-T8 771 L-EXTRUSION (R=0.1 AND Kt=1.0). Army.

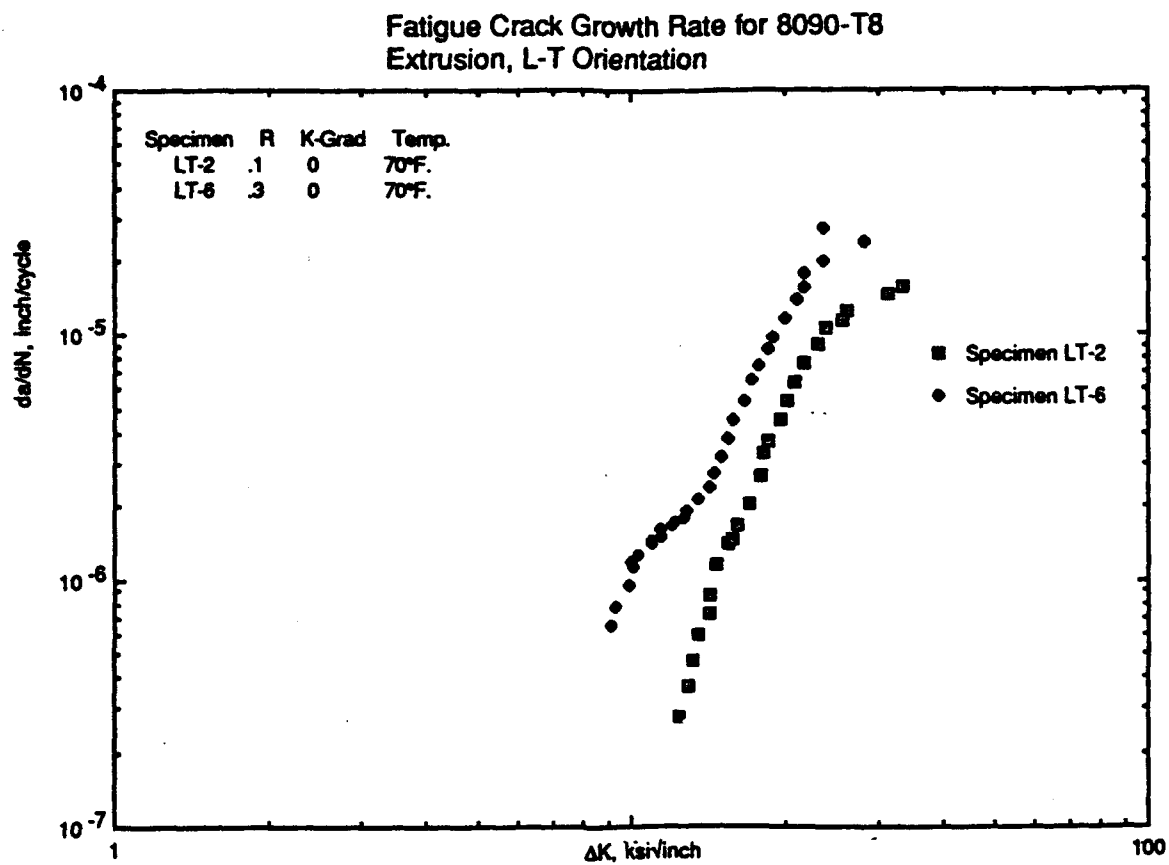


**FIGURE M4. FATIGUE CRACK GROWTH RATES for
8090-T8771 L-Extrusion (L-T Orientation).
Martin Marietta.**

TABLE M21
FATIGUE CRACK GROWTH RATE DATA ASSOCIATED WITH FIGURE M4
(Specimen P-411-LT-2)

Operator:	CPM	K Gradient:	0	
Sample date:	7/20/82	Min Load:	105 lbs.	
Material:	8080-T8 AL-LI	Max Load:	1050 lbs.	
ID #:	P-411-LT-2	Test Mode:	1	
Yield Strength	68,089 psi	Data Pt Intvl:	0.01 inch	
Modulus of Elasticity	11,283,333 psi	Min Growth Rat	0.000001 inch	
COO Pos:	2	Compl Slope:	2	
Crack Plane:	LT	Pts/Cycle:	200	
Geometry:	1	Upper Slope Limit	85	
Width:	1.1987	Lower Slope Limit	15	
Thickness:	0.5985	No of Slopes Ave.	5	
Half span (MT)	0	Compliance Correction	1.21449	
Environment:	AIR	Notch Length:	0.4757 inch	
Temperature:	69	Precrack Length:	0.5256 inch	
Humidity:	72	Precrack Cycle	552511	
Waveform:	1	Precrack Max Load	1206.64 lbs.	
Test Frequency	30	Precrack Min Load	120.819 lbs.	
Test Type:	1	#Points:	33	
Cycles	Crack Length, inch	da/dN, inch/cycle	dK, psi sqrt inch	Delta Load, lbs.
85101	0.5256	0	0	948.217
132924	0.5359	0	0	949.682
178420	0.5459	0	0	955.056
190090	0.5569	2.74E-07	12372	947.24
259515	0.5666	3.64E-07	12968	945.286
280660	0.5784	4.68E-07	13258	952.125
305150	0.5895	6.02E-07	13624	949.194
323275	0.6000	7.27E-07	14159	957.01
335375	0.6101	8.74E-07	14328	947.24
347470	0.6205	1.16E-06	14815	951.637
358560	0.6320	1.41E-06	15450	957.01
364825	0.6417	1.49E-06	15800	955.056
370025	0.6561	1.68E-06	16176	954.079
379780	0.6691	2.06E-06	17061	955.056
386520	0.6794	2.70E-06	17883	959.941
389570	0.6911	3.33E-06	18187	954.079
391950	0.7015	3.77E-06	18612	953.591
395340	0.7130	4.56E-06	19617	959.453
397385	0.7230	5.48E-06	20136	957.01
399430	0.7327	6.50E-06	20929	957.499
401145	0.7449	7.65E-06	21847	962.872
402955	0.7609	9.15E-06	23123	959.941
404565	0.7750	1.07E-05	23936	969.712
405610	0.7874	1.16E-05	25650	965.804
406850	0.8012	1.25E-05	26205	967.758
407690	0.8146	1.48E-05	31369	965.315
408735	0.8281	1.58E-05	33285	977.528
409780	0.8441	0	0	979.971
410155	0.8558	0	0	979.482
410865	0.8707	0	0	980.948
411240	0.8812	0	0	988.276
411610	0.8971	0	0	996.58
411985	0.9215	0	0	987.296

Final Cycle: 412200

Last Count: 1

Last Count 2: 1

Span: 100

Mean: 0

dA/dN method: 2

Poly points: 7

Start max kd: 1050.32 lbs.

Start max lc: 13570.1 psi sqrt inch

Notes:

Tests were performed with the "CGR Crack Growth Program" from Interlaken Version 1.54.

The crack lengths were corrected based on the final measurements.

The data was averaged using the 7 point polynomial method.

The precrack Pmax load of 1207 lbs. resulted in a delta 13% higher than the initial Pmax test load of 1050 lbs. did.

TABLE M22
FATIGUE CRACK GROWTH RATE DATA ASSOCIATED WITH FIGURE M4
(Specimen P-411-LT-6)

Operator:	cpm	K Gradient:	0	
Sample date:	7/20/92	Min Load:	315 lbs.	
Material:	8090-T8 Al-Li	Max Load:	1050 lbs.	
ID #:	P-411-LT-6	Test Mode:	1	
Yield Strength:	69,089 psi	Date Pt Invt:	0.01 inch	
Modulus of Elast:	11,283,333 psi	Min Growth Rate:	0.000001 inch	
COO Pos:	2	Compl Slope:	2	
Crack Plane:	LT	Pts/Cycle:	200	
Geometry:	1	Upper Slope Limit:	85	
Width:	1.2006 inch	Lower Slope Limit:	15	
Thickness:	0.5993 inch	No of Slopes Ave:	1	
Half span (MT):	0	Compliance Cor.:	1.08217	
Environment:	AIR	Notch Length:	0.4821 inch	
Temperature:	70 deg. F.	Precrack Length:	0.5403 inch	
Humidity:	72%	Precrack Cycles:	507*20	
Waveform:	1	Precrack Max Load:	1106.5 lbs.	
Test Frequency:	30 Hz	Precrack Min Load:	327.308 lbs.	
Test Type:	1	#Points:	42	
Cycles	Crack Length, inch	dA/dN, inch/cycle	dK, psi sqrt inch	Delta Load, lbs.
103	0.485	0	0	740.107
36189	0.494	0	0	752.32
58310	0.503	0	0	735.222
81006	0.514	0	0	740.107
100185	0.524	6.52E-07	9107	742.55
113915	0.536	7.74E-07	9330	744.993
135260	0.547	9.59E-07	9852	754.783
148590	0.557	1.14E-06	10082	749.878
151025	0.570	1.19E-06	9997	737.866
157296	0.579	1.27E-06	10343	749.878
168220	0.588	1.40E-06	10993	764.533
173375	0.600	1.46E-06	11020	752.32
181480	0.609	1.51E-06	11372	754.783
187530	0.620	1.62E-06	11498	744.993
194930	0.630	1.70E-06	12085	754.783
198720	0.639	1.71E-06	12191	749.878
204275	0.648	1.82E-06	12656	757.206
209510	0.660	1.92E-06	12884	749.878
217715	0.672	2.17E-06	13531	752.32
222070	0.681	2.42E-06	14216	769.419
225625	0.691	2.77E-06	14485	764.533
228855	0.700	3.21E-06	15068	774.304
232250	0.710	3.83E-06	15457	766.976
235010	0.719	4.55E-06	15893	762.091
237200	0.730	5.45E-06	16734	776.746
239155	0.741	6.57E-06	17245	771.861
240470	0.750	7.46E-06	17702	769.419
241940	0.760	8.77E-06	18571	774.304
242775	0.769	9.93E-06	18948	771.861
243926	0.781	1.18E-05	19924	774.304
244835	0.790	1.39E-05	21135	786.517
245506	0.799	1.57E-05	21593	786.517
246195	0.811	1.80E-05	21730	784.074
246710	0.821	2.01E-05	23694	788.959
247305	0.834	2.39E-05	28121	788.959
247820	0.845	2.70E-05	23738	801.172
248170	0.854	3.22E-05	41777	796.287
248525	0.866	0	0	793.845
248880	0.878	0	0	793.845
249155	0.892	0	0	808.5
249350	0.905	0	0	808.5
249465	0.916	0	0	813.385

Final Cycle: 249,555

Last Count: 43

Last Count 2: 1

Span: 100

Mean: 0

dA/dN method: 1

Poly points: 9

Start max load: 1052.76 lbs.

Start max lc: 13, 489 psi sqrt inch

Notes:

Tests were performed with the "CGR Crack Growth Program" from Interlaken, Rev. 1.54

The crack lengths were corrected based on the final measurements.

The data was averaged using the 9 point polynomial method.

Fatigue Crack Growth Rate for 8090-T8 Extrusion, T-L Orientation

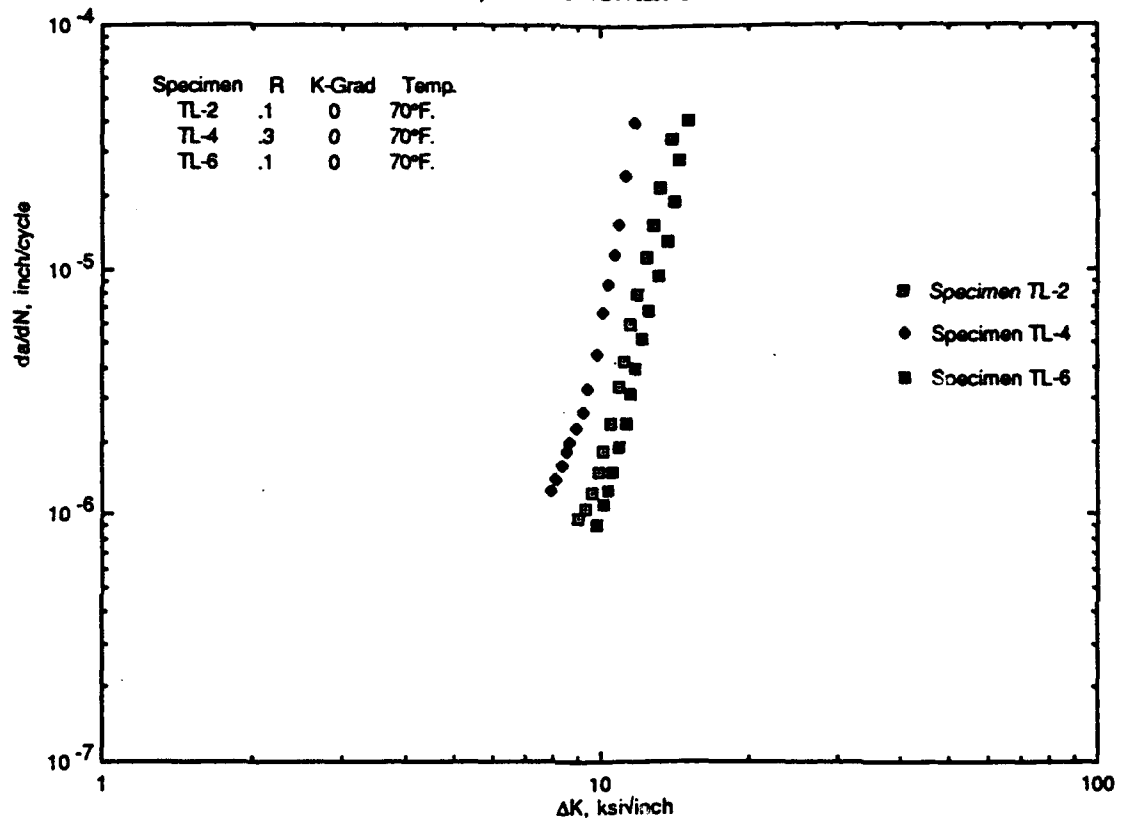


FIGURE M5. FATIGUE CRACK GROWTH RATES for
8090-T8771 L-EXTRUSION
(T-L Orientation).
MARTIN MARIETTA.

TABLE M23
FATIGUE CRACK GROWTH RATE DATA ASSOCIATED WITH FIGURE M5
(Specimen P-411-TL-2)

Operator:	cpm	K Gradient:	0
Sample date:	7/20/92	Min Load:	90 lbs.
Material:	8090-T8 Al-Li	Max Load:	900 lbs.
ID #:	P-411-TL-2	Test Mode:	1
Yield Strength:	55,209 psi	Data Pt Invt:	0.01 inch
Modulus of Elast:	9,253,333 psi	Min Growth Rate:	0.000001 inch
COD Pos:	2	Compl Slope:	2
Crack Plane:	TL	Pts/Cycle:	200
Geometry:	1	Upper Slope Limit:	85
Width:	1.1998 inch	Lower Slope Limit:	15
Thickness:	0.5993 inch	No of Slopes Ave:	1
Half span (MT):	0	Compliance Cor.:	23.0314
Environment:	AIR	Notch Length:	0.481 inch
Temperature:	71 deg. F.	Precrack Length:	0.542 inch
Humidity:	73%	Precrack Cycles:	232012
Waveform:	1	Precrack Max Load:	879.336 lbs.
Test Frequency:	30 Hz	Precrack Min Load:	75.7206 lbs.
Test Type:	1	#Points:	20

Cycles	Crack Length, inch	da/dN, inch/cycle	dK, psi sqrt inch	Delta Load, lbs.
102	0.4323	0	0	825.598
2593	0.4435	0	0	835.369
20719	0.4556	0	0	842.697
34715	0.4676	9.58E-07	9022	835.369
47520	0.4795	1.06E-06	9336	842.697
57690	0.4906	1.23E-06	9566	842.697
68185	0.5025	1.48E-06	9912	847.582
75330	0.5146	1.83E-06	10095	842.697
81600	0.5256	2.38E-06	10430	847.582
87780	0.5384	3.37E-06	10851	850.024
90445	0.5497	4.28E-06	11126	854.91
93675	0.5637	5.96E-06	11484	850.024
95460	0.5753	8.03E-06	11901	859.795
97165	0.5861	1.13E-05	12369	862.237
98235	0.5999	1.52E-05	12840	869.565
99145	0.6152	2.17E-05	13186	859.795
99695	0.6300	3.47E-05	13932	864.68
100400	0.6440	0	0	872.008
100590	0.6592	0	0	879.336
100780	0.6810	0	0	884.221

Final Cycle:	100820
Last Count:	21
Last Count 2:	21
Span:	100
Mean:	0
dA/dN method:	1
Poly points:	7
Start max kd:	906.24 lbs.
Start max k:	8539.27 psi sqrt inch

Notes:

Tests were performed with the "CGR Crack Growth Program" from Interlaken, Rev. 1.54
The crack lengths were corrected based on the final measurements.
The data was averaged using the 7 point polynomial method.

TABLE M24
FATIGUE CRACK GROWTH RATE DATA ASSOCIATED WITH FIGURE M5
(Specimen P-411-TL-4)

Operator:	cpm	K Gradient:	0
Sample date:	7/20/92	Min Load:	270 lbs.
Material:	6060-T8 Al-Li	Max Load:	500 lbs.
ID #:	P-411-TL-4	Test Mode:	1
Yield Strength	55209 psi	Data Pt Intvl:	0.01 inch
Modulus of Elasticity	9,263,333 psi	Min Growth Rate:	0.000001 inch
COD Position:	2	Compl Slope:	2
Crack Plane:	TL	Pts/Cycle:	200
Geometry:	1	Upper Slope Limit:	85
Width:	1.198 inch	Lower Slope Limit:	15
Thickness:	0.5983 inch	No of Slopes Ave:	1
Half span (MT)	0	Compliance Cor.:	1.04518
Environment:	AIR	Notch Length:	0.4788 inch
Temperature:	70 degrees F.	Precrack Length:	0.540 inch
Humidity:	72%	Precrack Cycles:	161228
Waveform:	1	Precrack Max Load:	889.106 inch
Test Frequency	30 Hz	Precrack Min Load:	236.932 inch
Test Type:	1	#Points:	21

Cycles	Crack Length, inch	da/dN, inch/cycle	dK, psi sqrt inch	Delta Load, lbs.
102	0.477122	0	0	666.83
8084	0.486919	0	0	661.944
17911	0.496762	0	0	664.387
28545	0.506321	1.24E-06	7908.28	669.272
34068	0.515525	1.40E-06	8103.03	671.715
40796	0.52494	1.60E-06	8284.49	671.715
46567	0.534579	1.80E-06	8532.1	676.6
51145	0.544001	2.00E-06	8642.17	671.715
55880	0.553252	2.27E-06	8911.49	676.6
60615	0.563792	2.65E-06	9217.21	681.485
63995	0.573166	3.30E-06	9352.74	676.6
67615	0.584118	4.57E-06	9760.35	683.928
69880	0.593493	6.68E-06	10104.7	688.813
70945	0.603432	8.70E-06	10314.4	691.255
72170	0.612938	1.16E-05	10651.5	693.698
72835	0.622871	1.52E-05	10873.5	693.698
73740	0.63399	2.43E-05	11343.3	693.698
74170	0.643239	4.02E-05	11815.2	701.026
74440	0.656417	0	0	701.026
74625	0.668738	0	0	703.468
74735	0.68147	0	0	713.239

Final Cycle:	74735
Last Count:	22
Last Count 2:	1
Span:	100
Mean:	0
dA/dN method:	2
Poly points:	7
Start max kt:	920.86
Start max k:	11229

Notes:
Tests were performed with the "CGR Crack Growth Program" from Interlaken Version 1.54.
The crack lengths were corrected based on the final measurements.
The data was averaged using the 7 point polynomial method.

TABLE M25

FATIGUE CRACK GROWTH RATE DATA ASSOCIATED WITH FIGURE M5

(Specimen P-411-TL)

Operator:	cpm	K Gradient:	0
Sample date:	7/20/92	Min Load:	90
Material:	8090-T8	Max Load:	900
ID #:	P-411-TL	Test Mode:	1
Yield Strength:	55,209 psi	Data Pt Intvl:	0.01 inch
Modulus of Elast:	9,263,333 psi	Min Growth Rate:	0.000001 inch
COD Pos:	2	Compl Slope:	2
Crack Plane:	TL	Pts/Cycle:	200
Geometry:	1	Upper Slope Limit:	85
Width:	1.197 inch	Lower Slope Limit:	15
Thickness:	0.5995 inch	No of Slopes Ave:	3
Half span (MT):	0	Compliance Cor.:	1.11667
Environment:	AIR	Notch Length:	0.477 inch
Temperature:	70 deg. F.	Precrack Length:	0.540 inch
Humidity:	72%	Precrack Cycles:	271,514
Waveform:	1	Precrack Max Load:	881.8 lbs.
Test Frequency:	30 Hz	Precrack Min Load:	68.4 lbs.
Test Type:	1	#Points:	21

Cycles	Crack Length, inch	da/dN, inch/cycle	dK, psi sqrt inch	Delta Load, lbs.
197	0.472871	0	0	836.183
26854	0.482567	0	0	838.626
38197	0.493092	0	0	840.254
46238	0.502636	9.03E-07	9757	838.626
59160	0.512279	1.10E-06	10100	841.882
67025	0.521875	1.26E-06	10300	842.697
75245	0.531116	1.50E-06	10612	847.582
82420	0.543787	1.90E-06	10857	844.325
88200	0.553981	2.35E-06	11172	845.953
93110	0.564713	3.10E-06	11544	848.396
95925	0.576008	3.97E-06	11799	850.024
99265	0.586188	5.33E-06	12232	850.839
101210	0.59915	6.88E-06	12581	852.467
103155	0.612628	9.47E-06	13117	856.538
104405	0.623243	1.32E-05	13605	858.166
105130	0.634197	1.91E-05	14096	865.494
105680	0.643813	2.80E-05	14430	860.609
106055	0.655555	4.07E-05	15019	869.565
106260	0.665858	0	0	865.494
106465	0.675114	0	0	867.123
106665	0.69	0	0	876.079

Final Cycle:	106,725
Last Count:	22
Last Count 2:	1
Span:	100
Mean:	0
dA/dN method:	1
Poly points:	7
Start max ld:	911.1 lbs.
Start max k:	10943.8 psi sqrt inch
Notes:	

Tests were performed with the "CGR Crack Growth Program" from Interlaken, Rev. 1.54
The crack lengths were corrected based on the final measurements.
The data was averaged using the 7 point polynomial method.

Fatigue Crack Growth Rate for 8090-T8 Extrusion, S-T Orientation

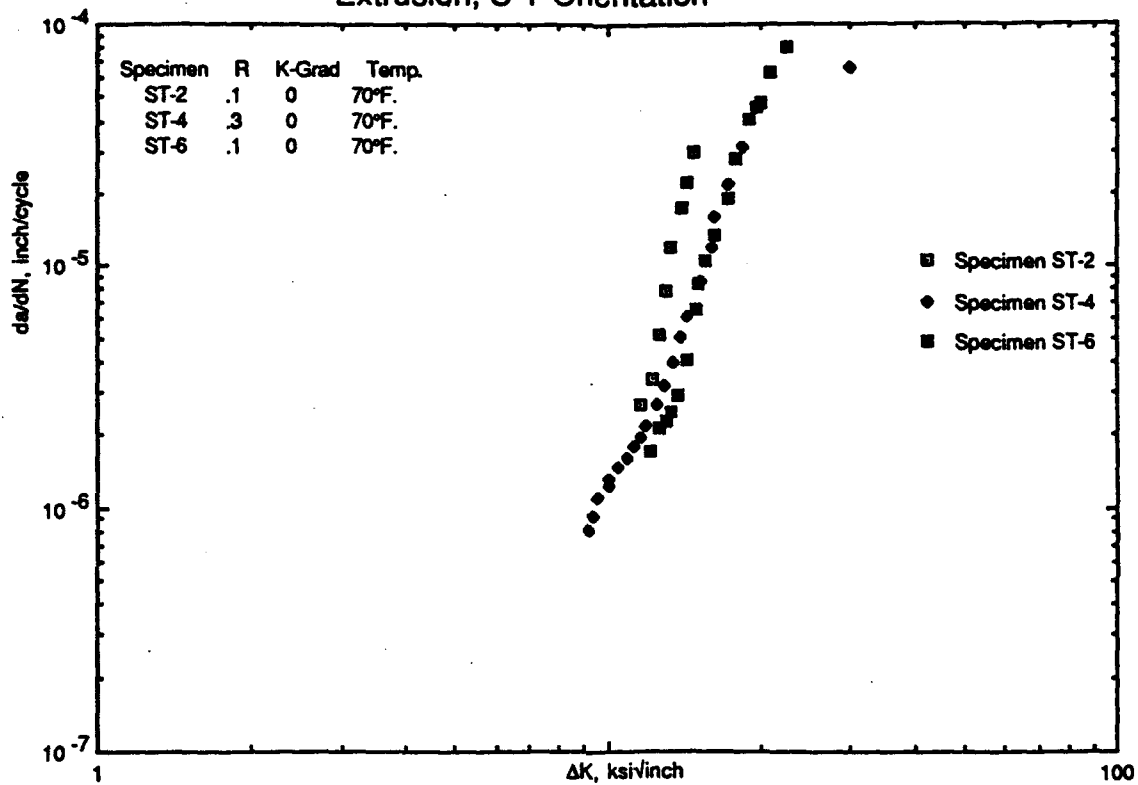


FIGURE M6. FATIGUE CRACK GROWTH RATES for
8090-T8771 L-EXTRUSION
(S-T Orientation).
MARTIN MARIETTA.

TABLE M26

FATIGUE CRACK GROWTH RATE DATA ASSOCIATED WITH FIGURE M6

(Specimen P-411-ST-2)

Operator:	cpm	K Gradient:	0
Sample date:	7/20/92	Min Load:	100 lbs.
Material:	8090-T8 Al-Li	Max Load:	1000 lbs.
ID #:	P-411-ST-2	Test Mode:	1
Yield Strength:	55,209 psi	Data Pt Intvl:	0.01 inch
Modulus of Elast:	9,263,333 psi	Min Growth Rate:	0.000001 inch
COD Pos:	2	Compl Slope:	2
Crack Plane:	ST	Pts/Cycle:	200
Geometry:	1	Upper Slope Limit:	85
Width:	1.2012 inch	Lower Slope Limit:	15
Thickness:	0.5987 inch	No of Slopes Ave:	5
Half span (MT):	0	Compliance Cor.:	1.1206
Environment:	AIR	Notch Length:	0.4817 inch
Temperature:	72 deg. F.	Precrack Length:	0.550 inch
Humidity:	70%	Precrack Cycles:	unrecorded
Waveform:	1	Precrack Max Load:	1070.7 lbs.
Test Frequency:	30 Hz	Precrack Min Load:	107.0 lbs.
Test Type:	1	#Points:	14

Cycles	Crack Length, inch	da/dN, inch/cycle	dK, psi sqrt inch	Delta Load, lbs.
291	0.507021	0	0	919.394
6500	0.51871	0	0	915.486
11636	0.532583	0	0	915.486
15696	0.545582	2.66E-06	11722	917.929
22717	0.558751	3.42E-06	12255	914.998
26777	0.571909	5.21E-06	12724	917.44
28956	0.584801	7.94E-06	13149	918.417
30058	0.596039	1.19E-05	13337	913.043
31158	0.606355	1.76E-05	13672	923.302
31720	0.620262	2.22E-05	14321	924.279
32287	0.631771	3.00E-05	14840	926.234
32851	0.650231	0	0	924.768
33419	0.669072	0	0	924.768
33716	0.6837	0	0	931.119

Final Cycle:	33867
Last Count:	15
Last Count 2:	1
Span:	100
Mean:	0
dA/dN method:	1
Poly points:	7
Start max load:	1006.35 lbs.
Start max K:	10501.5 psi sqrt inch

Notes:

Tests were performed with the "CGR Crack Growth Program" from Interlaken, Rev. 1.54

The crack lengths were corrected based on the final measurements.

The data was averaged using the 7 point polynomial method.

The precrack Pmax load of 1071 lbs. resulted in a delta 7% higher than the initial Pmax test load of 1000 lbs. did.

TABLE M27

FATIGUE CRACK GROWTH RATE DATA ASSOCIATED WITH FIGURE M6
(Specimen P-411-ST-4)

Operator:	cpm	K Gradient:	0
Sample date:	7/20/92	Min Load:	270 lbs.
Material:	8090-T8 Al-Li	Max Load:	900 lbs.
ID #:	P-411-ST-4	Test Mode:	1
Yield Strength:	55,209 psi	Data Pt Intvl:	0.01 inch
Modulus of Elast:	9,263,333 psi	Min Growth Rate:	0.000001 inch
COD Pos:	2	Compl Slope:	2
Crack Plane:	ST	Pts/Cycle:	200
Geometry:	1	Upper Slope Limit:	85
Width:	1.200 inch	Lower Slope Limit:	15
Thickness:	0.5997 inch	No of Slopes Ave:	1
Half span (MT):	0	Compliance Cor.:	0.640211
Env:	AIR	Notch Length:	0.4795 inch
Temp:	70 deg. F.	Precrack Length:	0.54 inch
Humidity:	72%	Precrack Cycles:	180,566
Waveform:	1	Precrack Max Load:	1038.1 lbs.
Test Frequency:	30 Hz	Precrack Min Load:	300.44 lbs.
Test Type:	1	#Points:	31

Cycles	Crack Length, inch	da/dN, inch/cycle	dK, psi sqrt inch	Delta Load, lbs.
204	0.535	0	0	644.846
1027	0.545	0	0	644.846
33151	0.556	0	0	647.289
58702	0.567	0	0	649.731
73082	0.577	8.18E-07	9080	652.174
84367	0.589	9.32E-07	9256	649.731
98972	0.600	1.10E-06	9541	649.731
109162	0.611	1.24E-06	9882	654.617
116227	0.624	1.33E-06	10141	649.731
124732	0.635	1.49E-06	10496	652.174
132042	0.647	1.61E-06	10913	657.059
141112	0.659	1.79E-06	11320	652.174
146817	0.670	1.97E-06	11647	652.174
150602	0.680	2.19E-06	11896	652.174
156782	0.691	2.67E-06	12497	657.059
160687	0.701	3.19E-06	12921	657.059
164677	0.712	3.99E-06	13517	661.944
167347	0.724	5.04E-06	13902	657.059
169057	0.735	6.21E-06	14443	664.387
171647	0.746	8.66E-06	15345	664.387
173037	0.757	1.21E-05	16059	664.387
173547	0.768	1.59E-05	16324	664.387
174372	0.778	2.16E-05	17294	669.272
175042	0.791	3.09E-05	18369	661.944
175472	0.806	4.60E-05	19981	676.6
175742	0.816	6.64E-05	29879	674.157
175937	0.829	0	0	676.6
176047	0.843	0	0	676.6
176157	0.856	0	0	683.928
176267	0.873	0	0	679.043
176382	0.891	0	0	681.485

Final Cycle:	176432
Last Count:	32
Last Count 2:	32
Span:	100
Mean:	0
dA/dN method:	1
Poly points:	9
Start max k:	908.647 lbs.
Start max k:	11,168.7 psi sqrt inch

Notes:

Tests were performed with the "CGR Crack Growth Program" from Interlaken, Rev. 1.54

The crack lengths were corrected based on the final measurements.

The data was averaged using the 9 point polynomial method.

The precrack Pmax load of 1038 lbs. resulted in a delta 14.6% higher than the initial Pmax load of 909 lbs. did

TABLE M28

FATIGUE CRACK GROWTH RATE DATA ASSOCIATED WITH FIGURE M6

(Specimen P-411-ST-6)

Operator:	cpm	K Gradient:	0
Sample date:	7/20/92	Min Load:	94 lbs.
Material:	8090-T8 Al-Li	Max Load:	940 lbs.
ID #:	P-411-ST-6	Test Mode:	1
Yield Strength:	55,209 psi	Data Pt Invt:	0.01 inch
Modulus of Elast:	9,253,333 psi	Min Growth Rate:	0.000001 inch/inch
COD Pos:	2	Compl Slope:	2
Crack Plane:	ST	Pts/Cycle:	200
Geometry:	1	Upper Slope Limit:	85
Width:	1.1992 inch	Lower Slope Limit:	15
Thickness:	0.5997 inch	No of Slopes Ave:	1
Half span (MT):	0	Compliance Cor.:	1.214
Env:	AIR	Notch Length:	0.4782 inch
Temp:	71 deg. F.	Precrack Length:	0.540 inch
Humidity:	72%	Precrack Cycles:	208,233
Waveform:	1	Precrack Max Load:	886.663 lbs.
Test Frequency:	30 Hz	Precrack Min Load:	68.3928 lbs.
Test Type:	1	#Points:	23

Cycles	Crack Length, inch	da/dN, inch/cycle	dK, psi sqrt inch	Delta Load, lbs.
103	0.546076	0	0	874.45
15442	0.556871	0	0	874.45
25448	0.567088	0	0	879.336
31625	0.577573	1.74E-06	12198	876.893
39313	0.590622	2.17E-06	12641	876.893
43733	0.602378	2.29E-06	13019	879.336
48073	0.613231	2.50E-06	13378	879.336
51940	0.623713	2.94E-06	13744	879.336
56996	0.634809	4.06E-06	14449	886.663
59680	0.644968	6.61E-06	14924	886.663
60806	0.656267	8.42E-06	15200	886.663
62190	0.666447	1.05E-05	15729	886.663
63180	0.682332	1.35E-05	16346	891.549
64330	0.692437	1.93E-05	17253	893.991
64915	0.703001	2.75E-05	17945	896.434
65506	0.72127	4.03E-05	19012	898.876
65690	0.73195	4.48E-05	19715	906.647
65800	0.742496	4.74E-05	19950	911.089
66225	0.757529	6.32E-05	21027	911.089
66415	0.770321	7.98E-05	22539	906.647
66606	0.781477	0	0	928.188
66715	0.800784	0	0	925.745
66825	0.812337	0	0	936.515

Final Cycle:	66900
Last Count:	1
Last Count 2:	0
Span:	100
Mean:	0
dA/dN method:	1
Poly points:	7
Start max load:	9,555 lbs.
Start max K:	12,313 psi sqrt inch

Notes:

Tests were performed with the "CGR Crack Growth Program" from Interlaken, Rev. 1.54

The crack lengths were corrected based on the final measurements.

The data was averaged using the 7 point polynomial method.